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ART. XXIII.—*Researches in Actino-Chemistry. Memoir First. On the Distribution of Heat in the Spectrum;* by JOHN WILLIAM DRAPER, M.D., LL.D., President of the Faculties of Science and of Medicine in the University of New York.

MANY experimenters at various times have occupied themselves with the problem of the Distribution of Heat in the Spectrum. At first it was supposed that there is a coincidence between the luminous and calorific radiations, and that the maximum of intensity in both occurs at the same point, that is, in the yellow space. This view was abandoned on the publication of the well known experiments of Sir W. Herschel, who showed that in certain cases the maximum is below the red. Subsequently Melloni having discovered the singular heat-transparency of rock-salt, proved that when a prism of that substance is used the maximum in question is as far below the red as the red is below the yellow, but that if the light has passed through flint-glass the maximum approaches the red, if through crown-glass it passes into the red, if through water or alcohol it enters the yellow.

In the case of the sun's spectrum the distribution of heat was more closely examined by Prof. Müller, whose results in a general manner confirmed the views then held, that the invisible radiation below the red greatly exceeds that in the visible spectrum; and still more recently Dr. Tyndall, examining the spectrum of the electric light through rock-salt, showed that the curve indicating the distribution "in the region of the dark rays beneath the red, shoots suddenly upward in a steep and massive peak, a kind of Matterhorn of heat, which quite

dwarfs by its magnitude the portion of the diagram representing the visible radiation." These investigations were made under unexceptionable circumstances; the beam of electric light had practically undergone no atmospheric absorption, and the optical refracting train was of rock-salt.

Sir J. Herschel had shown in 1840 that when the sun's rays are dispersed by a flint-glass prism, the distribution of the heat toward the less refrangible region is not continuous, but there are three maximum points. These points, as shown by Dr. Tyndall, do not exist in the spectrum of electric light, the decline of which is continuous; they are therefore to be attributed to the absorptive disturbance which the sun's rays have undergone. Quite recently (1871), M. Lamansky has succeeded in identifying these interruptions by the aid of the thermo-multiplier. In his memoir he states that, with the exception of Foucault and Fizeau, in their well known experiments on the interference of heat, no one has made reference to these lines, and that all experimenters describe the heat-curve as a continuous one (London and Edin. Phil. Mag., April, 1872).

I may therefore be excused for remarking at this point that the three lines in question were not only observed by me nearly thirty years ago, but that an engraving of them was published in the Philosophical Magazine, in a memoir announcing the discovery of fixed lines in the invisible portions of the spectrum (May, 1843). It will be seen, from an inspection of that engraving, that these lines are marked α, β, γ. They were impressed on daguerreotype plates, by resorting to the well known processes for obtaining photographs of the less refrangible regions of the spectrum.

In view of the preceding statement and others that might be given, it may, I think, be affirmed that the general opinion held at the present day as to the constitution of the spectrum is this, that there exists a heat spectrum in the less refrangible regions, a light spectrum in the intermediate, and a spectrum producing chemical action in the more refrangible regions. An experimental attempt to correct this view, and to introduce a more accurate interpretation, will not be without interest, especially as it is necessarily and directly connected with the important subject of photometry. In this memoir I shall offer some experiments and suggestions respecting the heat of the spectrum, and in another, shortly to be published, shall consider the distribution of the so-called chemical rays. Among the numerous problems of actino-chemistry there are none more important than these.

All the experiments hitherto made on the heat of the spectrum have been conducted on the principle of exposing a thermometer in the differently colored spaces. Such was Sir W.

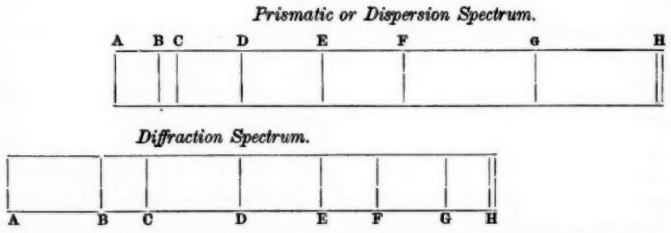
Herschel's method. Leslie used a differential with small bulbs. Melloni, Müller, Tyndall, a thermo-electric pile, the form preferred being the linear. This was advanced successively through all the radiations, and the deflections of the multiplier noted.

Is not this method essentially defective? Does it not necessarily lead to incorrect results?

"There is an inherent defect in the prismatic spectrum—a defect originating in the very cause which gives rise to that spectrum itself—unequal refrangibility. Of two groups of rays compared together, one taken in the red, the other in the violet region, it is clear that in the same spectrum, from the very circumstance of their greater refrangibility, those in the violet will be relatively more separated from each other than those in the red. The result of this increased separation in the more refrangible regions is to give an apparent dilatation to them, while the less refrangible are concentrated. The relative position of the colors must also vary: the fixed lines must be placed at distances greater than their true distances as the violet end is approached." I am quoting from the 5th chapter of a work "On the Forces which produce the Organization of Plants," published by me in 1844. In this chapter one of the chief points insisted on is the necessity of using wave-lengths in the measurement and discussion of spectrum results, a suggestion which I believe I was the first to make, and which I renewed in a memoir in the Philosophical Magazine (June, 1845).

The importance of these remarks respecting the peculiarities of the prismatic or dispersion spectrum, may perhaps be most satisfactorily recognized on examining such a spectrum by the side of a diffraction or interference one. By the aid of fig. 1 this may be done.

FIG. 1.



Regarding the space between the fixed lines D and E as representing the central region, in each the fixed lines D and E are made coincident. The other lines are laid off in the prismatic as they appear through the flint-glass prism of the spectroscope; those of the diffraction are arranged according to their

wave-lengths. It thus appears that in the prismatic, from the fixed line D to A, the yellow, orange, and red regions occupy but little more than half the space they do in the diffraction; while the green, blue, indigo, and violet, from the fixed line E to H, occupy nearly double the space in the prismatic that they do in the diffraction spectrum. The general result is that in the prismatic the less refrangible regions are much compressed, and the more refrangible much dilated. And it is plain that the same will hold good in a still greater degree for any invisible rays that are below the red and above the violet respectively.

Now if a thermometer of any kind were carried in succession from the greatly dilated, more refrangible regions to the greatly condensed, less refrangible, could the measures obtained be accepted as expressing the true distribution? The thermometric surface being invariable, would it not receive in the less refrangible spaces more than its proper amount of heat, and in the more refrangible less than its proper amount?

If we should admit that the distribution of heat in a correctly formed spectrum is uniform, it is plain that measures made by the use of a prism would not substantiate that admission. The concentration to which I have alluded as taking place in the less refrangible region would give an exaggerated, an increased heat for that region; and on the contrary, the dilatation of the more refrangible would give an exaggerated diminution of heat for that space. But if it were possible to make satisfactory heat measures on the diffraction spectrum, in which the colored spaces and fixed lines are arranged according to their wave-lengths, the admission would be substantiated.

In view of these facts I did attempt many years ago to make heat measures on the diffraction spectrum. But so small is the heat that, as may be seen in the Philosophical Magazine (March, 1857), the results were unsatisfactory. More recently I have tried another method of investigation, on principles which I will now explain.

For the sake of clearness, restricting our thoughts for the moment to the more familiar case of the visible spectrum, if we desired to ascertain the true distribution of heat, would not the proper method be to collect all the more refrangible rays into one focal group, and all the less refrangible into another focal group, and then measure the heat that each gave? If the view currently received be correct, would not nearly all the heat observed be found in the latter of these foci, and little, if indeed any, be found in the former? But if all the various regions of the spectrum possess equal heat-giving powers, would not the heat in each of these foci be the same?

Let us give greater precision to this idea. Using Angström's

wave-lengths—the length at the line A is 7604, and that at H^2 3933, and these lines are not very far from the less and more refrangible ends of the *visible* spectrum respectively. The middle point of this spectrum is at 5768, which may therefore be called its optical center. This is a little beyond the sodium line D, which is 5892. Now if by suitable means we reunite all the rays between 7604 and 5768 into one focus, and all the rays between 5768 and 3933 into another focus, are we not in a position to determine the true distribution of the heat? Should the heat at these two foci be sensibly the same, must not the conclusion at present held be abandoned?

If in these investigations the rays of the sun be used, it is necessary to restrict the examination to the visible spectrum, excluding the invisible red and invisible violet radiations. On these the earth's atmosphere exerts not only a very powerful but a very variable action, and what is still more, an action the result of which we cannot see, so that we are literally working in the dark. There are days on which, owing to the excessive absorption taking place among the ultra-red rays, a rock-salt train has no advantage over one of glass. But if it be the visible spectrum alone that we are using, and the prisms are of a material *colorless* to the eye, we may be certain that they are exerting no elective absorption on any of the radiations of that spectrum, and that the indications they are giving are reliable.

This variable absorptive action of the atmosphere depends partly on changes in the amount of water vapor, and partly on the altitude of the sun. At midday and at midsummer it is at a minimum. The disturbance is not merely a thermochrose, for both ends of the spectrum are attacked. It is a matter of common observation that the horizontal sun has but little photographic power, owing to atmospheric absorption of the ultra-violet rays, and under the same circumstances his heating power is diminished, owing to the absorption of the ultra-red rays. But if the day be clear and the sun's altitude sufficient, the visible spectrum may be considered as unaffected.

It should be borne in mind that the envelopes of the sun himself exert an absorptive action, which is powerfully felt in the ultra-violet region, as is indicated by the numerous fixed lines crowded together in that region. The force of this remark will be appreciated on examining the plate above referred to, in the Philosophical Magazine for May, 1843.

It seems then that all the conditions necessary for the solution of this problem will be closely approached if we make use of prisms constituted of any substance which is *completely colorless to the eye*, and confine our measures to the *visible spectrum*, collecting all the radiations between the fixed line A and the center of that spectrum just beyond D into one focus, and all

the radiations between that center and H^2 into another focus, and by the thermopile or any other suitable means measuring the heat of these foci.

Such is the method I have followed in obtaining the measures now to be presented: but before giving them there are certain preparatory facts which I wish to submit to the consideration of the reader.

(1.) In the mode of experiment hitherto adopted, no special care has been taken to ascertain with accuracy the position of the "extreme red," yet that is held to be the point from which on one side we are to estimate the invisible and on the other the visible spectrum. Different persons, perhaps because of a different sensitiveness of their eyes, will estimate that position differently. The red light shades off gradually—it is almost impossible to tell when it really comes to an end. A linear thermopile, such as is commonly used, is liable under these circumstances to give deceptive results, and any error in its indications counts in a double manner. It not only diminishes the value of one spectrum, but it adds that diminution to the value of the other. The force of this remark will be understood by considering the best experiments hitherto made on this subject, those of Dr. Tyndall, as related in his "Heat a Mode of Motion" (London edition, 1870, p. 420, &c.). In the case of the electric light, the result yielded by those experiments was that the heat in the invisible is eight times that of the visible region. But had there been an error in estimating the position of the extreme red by only two millimetres, so much would have been taken from the invisible and added to the visible, that they would have been brought to equality, and then the slightest turn of the screw that carried the pile toward the dark space would have given a preponderance to the visible. It is obvious, therefore, that there cannot be certainty in such measures, unless the fixed lines are resorted to as standard points.

(2.) A ray which has passed through a solution of sulphate of copper and ammonia possesses no insignificant heating power. I took a stratum of a solution of that salt, of such strength that it only permitted waves to pass which are of less length than 4860. Seen in the spectroscope, the colors transmitted through it commenced with a thin green fringe, followed by blue, indigo, violet. It therefore gave rays in which, according to the accepted views, little or no heat should be detected. Yet I found that such rays produced one-ninth of the heat of the solar beam. Does not this indisputably show that the more refrangible rays have a higher calorific power than is commonly imputed to them?

(3.) Again, by the use of the apparatus presently to be described, I found no difficulty in recognizing heat in the violet

region. But in the mode of conducting the experiment heretofore resorted to, it could not be detected in rays more refrangible than the blue. It was this result which gave so much weight to the conclusion, that in the more refrangible regions the calorific power is replaced by chemical force, and strengthened the idea commonly entertained that the solar radiations consist of three distinct principles, heat, light and actinism. In the memoir above referred to, as soon to be published, I shall present some facts which apparently make this view indefensible.

(4.) If waves of light falling upon an absolutely black surface, and becoming extinct thereby, are transmuted into heat, if the warming of surfaces by incident light be nothing more than the conversion of motion into heat—an illustration of the modern doctrine of the correlation of forces—heat itself being only "a mode of motion," it would seem extraordinary that the conversion should cease in the green or blue or in any middle ray. On the contrary, calorific effects ought to be traceable throughout the entire length of the spectrum. These views on the transference of motion from the ether to the particles of ponderable bodies and conversely, I endeavored to explain in detail in a memoir on Phosphorescence, inserted in the Philosophical Magazine, Feb. 1851, p. 98, etc. I had previously indicated them in the same Journal, Feb., 1847. A given series of waves of red light impinging upon an extinguishing surface will produce a definite amount of heat, and similar series of violet waves should produce the same amount. For though an undulation of the latter may have only half the length of one of the former, and therefore only half its *vis viva*, yet in consequence of the equal velocity of waves of every color, the impacts or impulses of the violet series will be twice as frequent as those of the red. The same principle applies to any intermediate color, and hence it follows that every color ought to have the same heating power.

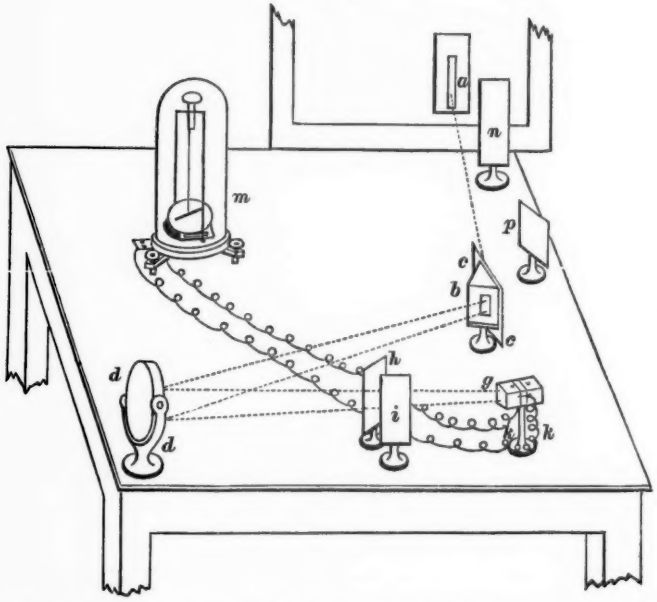
Description of the Apparatus employed.

The optical arrangement I have employed for carrying the foregoing suggestions into practice is represented by fig. 2, and in a horizontal section by fig. 3.

A ray of sunlight reflected by a Silberman's heliostat comes into a dark room through a slit *a* one millimeter wide. It then passes through a prism *b*. On the front face of this prism is a black paper screen *c c*, having a rectangular opening, just sufficient to permit the light of the slit to pass. After refraction the dispersed rays fall as a spectrum on a concave metallic mirror *d d*, nine inches in aperture and eleven in focus for parallel rays. I have sometimes used one of speculum metal, but more frequently one silvered on its front face. In front of

this mirror there are therefore three foci. At a distance of eleven inches there is one, *e*, fig. 3, giving a spectrum image of the sun. Still further there is a second, *f*, which is a spectrum image of the slit *a*, in which, if the prism be at its angle of minimum deviation, and the other adjustments be correctly made, will be seen the Fraunhofer lines. Again, still farther off, at *g*, is a focal image of the rectangular opening of the black paper *c c*, on the

FIG. 2.



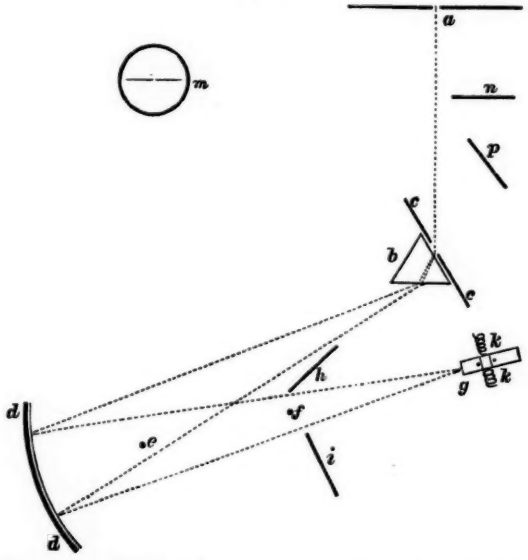
front face of the prism. This image, arising from the recombination of all the dispersed rays, is consequently white. The second and third foci are at distances from the mirror depending on the distance of the slit *a*, and the black paper *c c*, respectively.

With the intention of being certain that the light coming through the slit *a* is falling properly on the rectangular opening in the prism screen *c c*, a small looking-glass is placed at *p*. The experimenter, sitting near the multiplier *m*, can then see distinctly the reflected image of that opening.

At the place where the second focal image with its Fraunhofer lines forms, two screens of white paste-board, *h*, *i*, are arranged. By suitably placing the former of these, *h*, the more refrangible rays may be intercepted, and in like manner by the

other, *i*, the less refrangible. In using these screens, and particularly *h*, care must be taken that no rays passing from the prism to the mirror be obstructed, a remark that applies especially to the invisible rays of less refrangibility than the red. For this reason the mirror *d d* must be placed at such an obliquity to its incident rays as to throw the focal images sufficiently on one side. Yet this obliquity must not be greater than is actually necessary for that purpose, or the purity of the second spectrum, with its Fraunhofer lines, will be interfered with.

FIG. 3.



At the place of the third focus, arising from the reunion of the dispersed rays, is the thermopile *g*, connected by its wires *k k* with the multiplier *m*.

Whenever any of the visible rays of the Fraunhofer spectrum are intercepted by advancing either of the screens *h*, *i*, the image on the face of the pile ceases to be white. It becomes of a superb tint, answering to the combination of the non-intercepted rays. A slip of white paper placed for a moment in front of the pile will satisfy the experimenter how magnificent these colors are. It is evident, therefore, that by this arrangement the pile will enable us to measure the heat of any particular ray, or of any selected combination of rays. The screens can be arranged so us to reach any designated Fraunhofer line.

The pile I have used is of the common square form; a linear pile would not answer. The focal image on the pile is of very

much greater width than the slit *a*, on account of the obliquity of the front face of the prism.

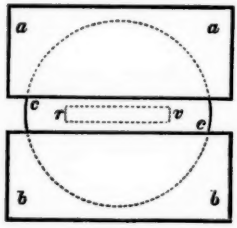
By removing the screen *h*, and placing the screen *i* so that its edge coincides with the line A of the Fraunhofer spectrum, all the invisible heat radiations of less refrangibility than the red are cut off, except the contaminating ones arising from the general diffusion of light by the substance of the prism. Under these circumstances the image on the pile will be white, and the multiplier will give a deflection representing the heat of the visible and the extra violet regions. If then the screen be advanced still further, until it has intercepted all the less refrangible regions up to the sodium line D or a little beyond, that is, to the optical center of the spectrum, the tint on the face of the pile will be greenish-blue, and the multiplier will give a measure of the heat of the more refrangible half of the visible spectrum, together with that of the ultra-violet rays; the latter portion may, however, be eliminated by properly using the other screen *h*.

Besides the error arising from stray heat diffused through the spectrum, in consequence of the optical imperfection of the prism, there is another which may be recognised on recollecting the relative positions of the prism, the concave mirror, and the face of the pile. It is evident that the prism, considered as a warm or a cool mass, is a source of disturbance, for the mirror reflects its image, that is, the image of the prism itself, to the pile. After the intromitted sunbeam has passed through the prism for a short time, the temperature of that mass has risen, and the heat from this source has become intermingled with the proper spectrum heat. But this error is very easily eliminated. It is only necessary to put a screen *n* in the path of the incoming ray, between the slit and the prism, and note the deflection of the multiplier. Used as we are here supposing, the multiplier has two zeros. The first, which may be termed the magnetic, is the position in which the needles will stand when no current is passing through the coil. The scale of the instrument should be set to this. The other, which may be termed the working zero, is formed by coupling the pile and the multiplier together, and introducing the screen *n* between the intromitting slit and the prism. On doing this it will probably be found that the index will deviate a few divisions. Its position should be accurately marked at the beginning and close of each set of measures, and the proper correction for them made. The disturbing influences of the mass of the prism, of the mirror, and of the pile itself, are thus eliminated. As respects the last, it should not be forgotten that it may be affected by changes in the position of the person of the experimenter himself.

With the intention of diminishing these errors, I have usually

covered the upper and lower portions of the concave mirror *d d* with pieces of black paper, so arranged as to leave a band of sufficient width to receive and reflect the entire spectrum. *a a*, fig. 4, is the upper paper, *b b* the lower, *c c* the uncovered reflecting band, receiving the spectrum *r v*. Had the spaces thus covered been permitted to reflect, they would have rendered more intense the image of the prism with its extraneous heat.

Fig. 4.



As regards the multiplier, care must be taken to avoid disturbance from aerial currents. I have one of these instruments of French construction, which could not be used in these delicate researches until proper arrangements were applied. It was covered with a glass shade. The slightest cause occasioned currents in its included air, which perpetually drifted and disturbed the needles. For this reason, and also for more accurate reading, it is best to view the position of the index through a small telescope.

The combination of needles being nearly astatic, attention must be paid to their magnetic perturbations, whether arising from local or other causes; and, since the vibrations are very slow, ample time must be given before the reading is ascertained.

The condition of the face of the pile is of importance. It must be such as to extinguish as completely as possible all the incident rays. To paint it with lamp-black, mixed with gum, will not answer—the surface so produced is too glossy and reflecting. The plan I have found best is to take a glass tube half an inch in diameter and six inches long, open at both ends. and use it as a chimney. A piece of camphor being set on fire at the lower end, and the face of the pile to be blackened being held for a moment at the upper, it is covered with a dense black film, without any risk of injury to the pile. Even at the best, when this has been done, there is an unavoidable source of error in the want of perfect blackness of the lamp-black. It is sufficient to inspect the face of the pile when receiving rays from the concave mirror to be satisfied how large a portion of light is reflected. The experiments of Dr. Tyndall show that this substance also transmits a considerable percentage of the heat falling on it. Its quality of transmitting light is well known to every one who has looked at the sun through a smoked glass.

The galvanometer I have used is calibrated according to the usual method. The numbers given in this memoir do not represent the angles of deflection, but their corresponding forces.

The proper position of the intercepting screens *h*, *i*, can often be verified with precision by looking through blue cobalt glass. This glass insulates a definite red, an orange, and a yellow ray in the less refrangible regions, and then commencing with the green, gives a continuous band to the end of the violet. Its red ray begins at the less refrangible end of the spectrum, and ends near C; it includes the fixed lines A, B, C. Its orange ray lies wholly between C and D, including neither of those lines. Its yellow ray begins near 5894, and ends about 5581; the line D is therefore near its point of beginning. The remaining continuous band begins about 5425; it therefore includes the lines E, *b*, F, G, H. I have found this glass of much use in determining how far the screen *i* has been pushed. It is convenient to select a light kind of it, and by looking through one, two, or three pieces, the depth of color can be regulated at pleasure.

The optical train which has acted on the sunbeam under examination is therefore (1) the sun's atmosphere; (2) the earth's atmosphere: (3) the heliostat mirror of speculum metal; (4) the prism; (5) the concave mirror of silvered glass; (6) the blackened face of the thermopile.

Results obtained by the Apparatus.

We are now ready to examine the results which this optical apparatus yields, it having been of course previously ascertained that the reflecting band of the concave mirror *d d* is sufficient to receive all the radiations coming from the prism, and that none are escaping past its edges.

The operations required are as follows:

The heliostat is to be set, and its reflected ray brought into the proper position. The optical train is adjusted, the prism being at its minimum deviation, and the concave mirror giving a white image on the face of the pile.

The screen *h* is then to be placed so that, without intercepting any rays coming from the prism to the mirror, it cuts off all the Fraunhofer spectrum above H^2.

The screen *i* is so placed as to cut off all rays less refrangible than the sodium line D. More correctly, the screen should be a little beyond D. The light on the face of the pile will now be greenish-blue.

The screen *n* is then placed so as to intercept the intromitted beam. When the needles of the multiplier come to rest they give the working zero, which must be noted.

The intromitting screen *n* being now removed, the multiplier will indicate all the heat of the more refrangible rays, that is from a little beyond D up to H^2. The force corrected for the working zero is to be noted.

The screen *i* is then removed to the line A, so as to give all the radiations between the lines A and H^2. The light on the

face of the pile is white, and the multiplier gives the whole heat of the visible spectrum. By subtracting the foregoing measure from this, we have the heat of the less refrangible region, that is from A to the centre of the spectrum.

As a matter of curiosity, the experimenter may now, if he pleases, remove the screens *h*, *i*; the light on the face of the pile will still be white, and the multiplier will give the force of the entire radiations, except so far as they are disturbed by the thermochrose of the media. These measures, as not bearing upon the problem under consideration, I do not give in the following tables.

Instead of advancing the screen *i* from the less toward the more refrangible regions, I have very frequently moved *h* from the more refrangible to the less. When it is brought down from H^2 to the centre of the spectrum, the light on the face of the pile is of an intense orange-red—it might perhaps be called a bromine-red. I need not give further details of this mode of experimentation, as I did not find that its results differed in any important degree from those obtained as just described.

The variation in different experiments may generally be traced to errors in placing the screen *i* with exactness on the centre of the spectrum and on the line A.

For the sake of more convenient comparison, I have reduced all the different sets of experiments to the standard of 100 for the whole visible spectrum.

I have made use of four prisms: (1) rock salt; (2) flint glass; (3) bisulphide of carbon; (4) quartz, cut out of the crystal so as to give a single image.

All the observations here recorded were made on days when there was a cloudless sky.

TABLE I.—*Distribution of heat by rock-salt.*

	Series I.	Series II.
(1) Heat of the whole visible spectrum,.....	100	100
(2) " more refrangible region,.....	53	51
(3) " less " "	47	49

In this table the column marked Series I. gives the mean of four sets of measures, and that marked II. of three. At the beginning of each set the rock-salt was repolished.

TABLE II.—*Distribution of heat by flint-glass.*

	Series I.	Series II.
(1) Heat of the whole visible spectrum,.....	100	100
(2) " more refrangible region,.....	49	52
(3) " less " "	51	48

Series I. gives the mean of ten sets of measures, Series II. of eight.

TABLE III.—*Distribution of heat by bisulphide of carbon.*

		Series I.	Series II.
(1)	Heat of the whole visible spectrum,.....	100	100
(2)	" more refrangible region,.....	52	49
(3)	" less " "	48	51

The sulphide employed was devoid of any yellowish tinge; it was quite clear. Series I. is the mean of eight experiments, Series II. of ten.

TABLE IV.—*Distribution of heat by quartz.*

		Series I.	Series II.
(1)	Heat of the whole visible spectrum,.....	100	100
(2)	" more refrangible region,.....	49	53
(3)	" less " "	51	47

Series I. represents twenty-seven experiments, Series II. twelve. In the former two quartz prisms were used to increase the dispersion; in the latter only one was employed.

Perhaps it may not be unnecessary for me to say that I have repeated these experiments many hundred times during a period of several months, including the winter and the summer, varying the conditions as to the hour of the day, arrangement of the apparatus, &c., as much as I could, and present the foregoing tables as fair examples of the results. Apprehending that the heliostat mirror, which was of speculum metal, might exert some disturbing influence on account of its faint reddish tinge, I replaced it with one of glass silvered on the front face, but could not detect any substantial difference in the results.

The important fact clearly brought into view by these experiments is, that if the visible spectrum be divided into two equal portions, the ray having a wave-length of 5768 being considered as the optical center of such a spectrum, these portions will present heating powers so nearly equal that we may impute the differences to errors of experimentation. Assuming this as true, it necessarily follows that in the spectrum any two series of undulations will have the same heating power, no matter what their wave-lengths may be.

But this conclusion leads unavoidably to a most important modification of the views now universally held as regards the constitution of the spectrum. When a ray falls on an extinguishing surface heat is produced, but that heat did not preexist in the ray. It arose from the stoppage of ether waves, and is a pure instance of the conversion of motion into heat—an illustration of the modern doctrines of the conservation and transmutation of force.

From this point of view the conception that there exists in an incident ray various principles disappears altogether. We have to consider an incident ray as consisting solely of etherial

vibrations, which, when they are checked by an extinguishing substance, lose their *vis viva*. The effect that ensues depends on the quality of the substance. The vibrations imparted to it may be manifested by the production of heat, as in the case of lamp-black, or by chemical changes, as in the case of many of the salts of silver. In the parallel instance of acoustics clear views have long ago been attained, and are firmly held. No one supposes that sound is one of the ingredients of the atmosphere, and it would not be more incorrect to assert that it is something emitted by the sounding body, than it is to affirm that light or heat, or actinism, are emitted by the sun.

The progress of actino-chemistry would be greatly accelerated if there could be steadfastly maintained a clear conception of the distinction between the mechanism of a ray and the effects to which that ray may give rise. The evolution of heat, the sensation of light, the production of chemical changes, are merely effects—manifestations of the motions imparted to ponderable atoms,—and these in their turn can give rise to converse results, as when we gradually raise the temperature of a substance the oscillating movements of its molecules are imparted to the ether, and waves of less and less length are successively engendered.

In the title of this memoir I have employed the phrase "Distribution of Heat," in accordance with general usage; but if the conclusion arrived at be true, it is plain that this should be exchanged for "Production of Heat." The heat observed did not pre-exist in the incident rays: it is the result of their extinction.

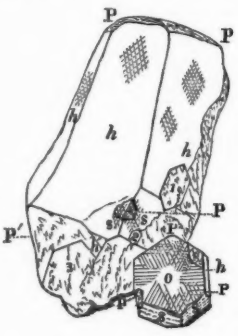
The remark has been made that these results are essentially connected with photometry. In fact, any thermometer is converted into a photometer, if its ball or other receiving surface be coated with a perfectly opaque non-reflecting substance.

ART. XXIV.—*On the Corundum region of North Carolina and Georgia, with descriptions of two gigantic crystals of that species;* by CHARLES UPHAM SHEPARD, Sr., Prof. of Natural History in Amherst College, Mass.

(Concluded from page 114.)

IT remains to speak of the corundum itself. This may be said to be eminently crystalline throughout, often in tolerably perfect crystals of considerable size, in a few instances, gigantic. Their form, as usual, is that of six-sided prisms or pyramids, sometimes the two combined; and exhibiting occasional triangular faces belonging to the primary rhombohedron. Whether

massive or crystallized however, it is readily cleavable; and the crystals are remarkable for showing cleavage lines, whereby their faces are transversely ruled off into lozenge-shaped areas, often in a very beautiful manner. The prevailing colors are blue and red, the latter often of a deep tint and handsome. The blue is intense only in small patches, and shades off into gray or pale yellowish gray. Thus far I have seen no single crystal, however small, sufficiently free from a tendency to cleavage, to answer the purposes of jewelry; though some of the larger crystals of the blue variety might perhaps afford portions pure enough for ring-stones. In a few cases I have seen pale yellow and apple-green colors. The crystals are generally rather remarkable for their translucency and internal regularity. Their unfitness for cutting, therefore, would appear to result from their too easy cleavage, rather than from other causes. The same crystal often combines the red and blue shades of color; the latter tint, if the form is pyramidal being the deepest at the base, and evincing a tendency to traverse the center of the crystal nearly to its apex, where the ruby color wholly replaces it, and sometimes here presents itself with much intensity. The faces differ considerably in smoothness and luster. Those belonging to the prism, the primary rhombohedron, and the face perpendicular to the axis, being the most perfect; while those of the pyramids are the most deficient in finish. In size, the crystals vary from a quarter of an ounce up to a pound in weight, though the latter are rare; while two have been found of very extraordinary magnitude. The largest of these weighs 312 pounds, the smaller 11¾ pounds. The annexed wood-cut, sketched from a photograph, will give some idea of their comparative dimensions. It represents them at about one-tenth the natural size.



The largest of the two is red at the surface, but within of a bluish-gray. This was found by Col. Jenks last autumn at the Culsagee mine, Macon Co., N. C.; and occurred in a layer of soft, almost pulverulent, vermiculite, within four feet of the surface of the ground. We undoubtedly owe the very perfect preservation of its form to the soft material in which it was reposited. Had it occurred at a greater depth in the stratum, where the gangue is an unaltered ripidolite, its extrication except in fragments, would have been impossible. The general figure is pyramidal, showing, however, scarcely more than a single six-sided pyramid, whose summit is

terminated by rather an uneven and somewhat undefined hexagonal plane. Two opposite faces of this pyramid are produced to nearly double the width of its remaining four, which imparts a wedge-shaped or flattened aspect to the crystal. Its length is 22 inches, its greatest breadth 18, its thickness 12. The angles as approximately determined are, h on $h = 124°$, h on $h' = 139°$, s on $s = 120°$, P (cleavage plane) on $s = 137°$. The letters P refer to cleavage planes: figures 1, 2, and 3 to hexagonal crystals projecting from the sides of the main crystal. The first of these (1) is red only near its surface; within, it is bluish-gray, as indeed the large crystal itself seems to be, since such is the color of the entire central region of the broad cleavage face P′. The lower part of the crystal, as well as a large part of the broad right hand face h, is largely covered by implanted crystals and laminæ of deep green ripidolite, some of which are an inch or more in diameter. The adjoining pyramidal face h also displays here and there small imbedded hexagonal plates of the same species. The color of the four narrow planes is a pale pink or rose-red, that of the two broader planes is a dark purple. The surfaces of the first-mentioned set are somewhat rough, as if from erosion or a partial disintegration, resulting perhaps from the very easy cleavage of the external layers; but the broad faces retain their original smoothness and polish. On both sets, however, the lines of cleavage are very striking. An attempt to represent them in the figure is made at a few places by trellised lines, which may be taken as a picture of the whole surface of the crystal, excepting the region indicated by other shadings, where the ripidolite abounds. The small triangular space between s and s refers to a cleavage face parallel with one of the primary planes.

The smaller of the crystals represented in the wood-cut is a regular hexagonal prism, well terminated at one of its extremities, the other being drusy and incomplete. One of its lateral planes is reduced one-half in its dimensions, through the presence of the pyramidal face h. The letters P denote the existence of incipient cleavage planes, parallel with the primary rhombohedron; while the crossing lines on o are to show the lines of cleavage, coincident with the upper edges of the laminæ. The meeting of these lines at the center impart a stellular aspect to this terminal plane. The crystal is incomplete, as will appear from the circular shading at one of its angles. This defect extends, however, to less than one inch in depth, where the surface becomes very uneven, from being coated by a brown vermiculite, or altered ripidolite. Some of the lateral planes are coated in patches with a white pearly margarite. The general color of the crystal is a grayish-blue, though there are spots, particularly near the angles, where it is of a pale sapphire tint. Its greatest

breadth is six inches, and its length rather above five. This specimen also was found by Col. Jenks, while exploring for corundum at a new locality in Rabun Co., Ga., at a spot about 16 miles west from Walhalla (S. C.), a little north of the proposed route of the Rabun Gap railroad. The associated minerals here are described by Col. Jenks as similar to those at the Culsagee mine.

It may not be out of place to append to the foregoing a few observations upon the minerals associated with corundum at other localities. The most important of these in the United States is that at Chester, Mass., already widely known as the emery mine, a deposit forming a well defined vein or stratum, several feet in thickness, and running without interruption a distance of several miles. Emery, as is well known, puts on an appearance very different from corundum, though from its great hardness and intimate admixture with pure corundum, it has always been regarded as a variety of this species. Its peculiarity arises from its being an aggregate of corundum and magnetite. This fact is well seen at the Chester mine, the proportion of the two species here varying indefinitely from the merest sprinklings of almost invisible octahedral crystals of magnetite through the grains and crystals of corundum, up to absolutely pure massive magnetite, which itself sometimes fills almost the entire vein for a distance of rods, to the apparent exclusion of all traces of corundum. There occur again considerable stretches of the vein, consisting of almost pure corundum, or at least of this species only blended with the chloritic gangue.

In noting the associated rocks and minerals, we here find a hornblendic gneiss (with considerable epidote) on one side of the vein (rarely on both sides), and talcose slate or steatitic "pseudo-serpentine" on the other, in both of which rocks minute grains of corundum are found, at least for a short distance from the vein. In one place this hard gray serpentine has a dolomitic character; and the emery vein itself often contains narrow seams, a few inches long, of pure white and sparry dolomite, in which small crystals and grains of sapphire may frequently be detected. Rutile and corundophilite usually accompany this dolomite. Margarite in veins and balls, from half an inch to two inches in thickness, made up of broad rose-colored laminæ, placed at right angles to the sides of such veins, are frequent in the emery. In a somewhat similar manner, though much more rarely, the diaspore is here found. Epidote in slender radiating crystals is another characteristic species of the locality. In one portion of the vein a blackish-brown tourmaline is abundant; and not far distant the walls and joints of the vein are coated by a greenish-black chloritoid. Very thin laminæ of ilmenite have also been met with in connection

with the margarite and other imbedded minerals. The amphodolite or indianite variety of anorthite also occurs at a few places. These are all the minerals thus far distinguished as proper to the vein. But of these it should be stated, that the magnetite constitutes at least one-third of its contents; next in abundance comes the chloritic mineral, corundophilite, forming, perhaps, one-eighth, while all the other species constitute in their entire aggregate less than one hundredth.

The North Carolina and Georgia regions chiefly differ from the Chester, then, in the absence of magnetite (and accordingly of emery), rutile and diaspore; and in having zoisite instead of epidote, ripidolite in place of corundophilite, and albite for anorthite. Besides, both the soda hornblende (arfvedsonite), so frequent in N. C., and the spinel, are wholly absent at Chester. But the two formations agree in the contiguity very largely of magnesian minerals, in the total absence of quartz and mica, and, in general, in the low proportion of silicic acid.

The corundum region of Franklin, Newton and Vernon of New Jersey and its prolongation at Warwick, N. Y., is characterized throughout by closely agreeing features. The gangue is a dolomitic limestone, in which it exists in isolated masses or pockets. It is generally crystallized, and either of a sapphire or ruby color. Its associates are spinel (which is either red or gray), rutile, biotite (phlogopite), a brown hornblende, a grass-green arfvedsonite, a peculiar feldspar, and more rarely, margarite and chondrodite (the latter sometimes changed into serpentine). Thus far, neither magnetite nor diaspore have been detected as occurring in the aggregate at these places.

Biotite here seems to take the place of the chloritic minerals found so often with corundum elsewhere, and spinel that of magnetite. But in the absence of quartz and the prevalence of magnesia, we discover a marked similarity of conditions with the N. C. and Chester localities.

Concerning the localities in Delaware and Chester counties, Pa., I am unable to speak definitely. But all the specimens of corundum I have examined from that region evince the absence of quartz; and seem to show that tourmaline, margarite and albite are its constant associates. At Clubb Mountain, Lincoln county, N. C., an entirely distinct region from that in the Blue ridge first described, the corundum is mixed with margarite and rutile. The specimens of blue corundum found within a few years at Pelham, Mass.,* were in fragments associated with biotite, and also distributed through vermiculite. The corundum found in balls of cyanite at Litchfield, Conn., is constantly associated with talc and diaspore; while the small sapphire

* See this Journal, vol. xi, ix, p. 271.

crystals occurring at Norwich, Conn., were completely surrounded by the allied species, fibrolite.

Dolomitic limestone constitutes the chief repository of corundum in other countries, as at Campo Longo, St. Gothard; and of the emery, according to Dr. J. Lawrence Smith, in the Turkish dominions, where he has pointed out the margarite, diaspore and chloritoid as its distinguishing attendants.

The examples from Mozzo, Piedmont, show a gangue of some compact species of feldspar; but, it is noticeable, with the exclusion of all adhering quartz. The precious corundum (sapphire and ruby) coming from Ceylon in crystals, mingled with red spinel, as the produce of river washings, may fairly be presumed to have originated in dolomitic limestone; while the larger crystals and cleavable masses from Ava, Hindostan, Thibet and China, as well as those from the Urals, were probably afforded by a region in some respects similar to that of the mountainous district of Georgia and North Carolina; but of the minerals immediately associated with it in those countries we possess no reliable information.

Amherst College, June 8, 1872.

ART. XXV.—*Notice of some of the works of J. Barrande, with extracts from his remarks with reference to the mode of origin of Paleozoic species.**

1. **Trilobites.** Extrait du Supplément au vol. i. du Système Silurien du centre de la Bohême. Prague, 1871. 8vo, 282 pp.
2. Système Silurien du centre de la Bohême: vol. ii, Céphalopodes; 4me Series, Pl. 351 à 460. 4to. Prague, 1870.
3. Syst. Sil. etc.; Céphalopodes; 4me Series; Distribution horizontale et verticale des Céphalopodes, dans les Contrées Siluriennes. 4to. Prague, 1870.

THE receipt of the above-named volumes, which we owe to the kind courtesy of the author, Mr. Joachim Barrande, of Prague, Bohemia, gives us a favorable opportunity for noticing the extended and valuable labors of this accomplished naturalist.

For forty years or more, he has made the study of the Silurian strata of Bohemia and of their fossils his principal object. His first publication was a brief "Preliminary Notice of the Silurian System and the Trilobites of Bohemia," issued in Leipzig in 1846. This was followed, in 1847 and 1848, by a brief notice of the Bohemian Brachiopoda, published in two parts, at

* Prepared for this place by Professor Frank H. Bradley of Knoxville, Tennessee.

Vienna, and, in 1850, by a paper on the Graptolites of Bohemia. In 1852, he commenced the publication of the large quarto series of detailed descriptions of Bohemian Silurian fossils, with abundant and excellent illustrations, of which two volumes are named above. The first issue was the volume of Trilobites, in two parts, 935 pages of text and 52 plates, published in 1852. Of vol. ii, which includes the Cephalopods, the first livraison, including 107 plates, appeared in 1865, followed, in 1866, by the second, which includes plates 108 to 244. The first livraison of text, consisting of 712 pages, appeared in 1867, and was followed, in 1868, by the third series of plates, including Nos. 245–350. The fourth and final series of plates, including Nos. 351–460, which is named at the head of our article, appeared in 1870, accompanied by a volume of 263 pages of supplementary text, treating especially of the distribution of Silurian Cephalopods. Volume iii. of the series, including the Pteropods of the Bohemian Silurian, and consisting of 179 pages of text and 16 plates, appeared in 1867. We still look for the supplement to the volume on Trilobites, for the remaining livraison of the text of vol. ii, which is to include the descriptions of the species of *Orthoceras*; for the volumes which are to include the Gasteropods, Conchifers, Brachiopods and Radiates; and for the final one which is to give us all the details of the stratigraphical and lithological geology of the Bohemian basin. As a whole, these volumes will constitute one of the grandest monuments ever erected to the energy, skill, patience and industry of one man, as well as to the constant liberality of his munificent patron, the Count de Chambord.

Besides this quarto series, Mr. Barrande has issued, for more general distribution, a series of octavo pamphlets, including the general conclusions announced in his larger works, but not repeating specific descriptions, although they have been issued generally in advance of the appearance of the volumes which they represent, thus showing that his object has been purely the spread of information rather than personal credit for priority. Of this series, we name one at the head of our article. He has also issued four pamphlets, entitled "Dèfense des Colonies," of which we propose to speak further on another occasion.

Of the volumes now before us, we can truly say that they are worthy successors to those previously published. The plates most fully and elegantly illustrate the remaining species of the Cephalopoda, and include many additional figures of species already illustrated in the earlier plates.

The supplementary text of the Cephalopods includes a thorough study and full summary of the general and detailed facts of their distribution, at least so far as Silurian forms are concerned, together with many later ones. This comprises so much

interesting matter, that we feel justified in making considerable extracts, especially from the closing *Résumé général:*—

"I. *Relative importance of Cephalopods.* As regards organization, this order [Cephalopoda] is the first among Mollusks. It can also be considered as occupying the first rank among the orders represented in the Silurian faunas, if we except the Fishes, which appeared sporadically, at some isolated points, toward the end of this great period. We ought, however, to refrain from judging absolutely as to the relative preëminence of organization in the Cephalopods and the Trilobites, because the elements from which this preëminence could be determined are forever withdrawn from the comparative observations of science. We know, moreover, that zoölogy possesses no incontestable rule for exactly measuring and weighing the grade of organization of animals which belong to different classes or subkingdoms. As regards the power or physical force indicated by the dimensions of the shells of many species, there is no doubt that the Cephalopods enjoyed great superiority among the beings which animated the Silurian seas, at least during the continuance of the second and third faunas. They were, then, during these long ages, the veritable rulers of the ocean. This predominance cannot be disputed, except toward the end of the third fauna, the epoch of the appearance of the first Fishes and of the powerful Crustaceans of the genus *Pterygotus*, belonging to the family of *Eurypteridæ*. As regards prolific power, *i. e.*, the frequency of individuals, which is also indispensable for exercising domination in the sea, it would be impossible for us to decide whether the Cephalopods surpassed the Trilobites, since, in these two faunas [second and third] the remains of individuals of the two groups occur in myriads, and are equally innumerable.

Thus far, the Cephalopods may be considered as occupying or disputing the first rank * *, but, in other respects, we must perceive that the preëminence belongs to the tribe of Trilobites. They possess, in the first place, an incontestable and well-marked preëminence over the Cephalopods as regards priority. We know, in fact, that this tribe of Crustaceans constitutes by itself almost the whole of the Primordial Silurian fauna. The number of genera and species by which it is represented in this fauna is already very considerable, and we see that it tends to increase constantly, especially in England and America. * * No authentic trace of Cephalopods has yet been recognized in the same formations. The great prolific power of the Mollusks of this order in the second and third faunas authorizes us to think that, if they had existed under various generic and specific forms in the Primordial fauna, we should find their remains as frequent as those of the Trilobites in the

formations which inclose this fauna. And as the first appearance of each order or of each important family is habitually announced, in the geological series, by some sporadic or prophetic forms, we long looked forward to the discovery of similar precursors of the Cephalopods in the Primordial fauna; but our expectation has not yet been realized. In any case, we cannot deny that the Trilobites had the privilege of being called into existence long before the Cephalopods. As regards the number of generic types of Trilobites, * * we judge that it may well amount to triple the number of the types of Cephalopods, which is 25, according to our classification. The advantage of the Trilobites, in this respect, is then very decided. Still, it would be notably reduced, if we deduct the types which exist only in the Primordial fauna. As regards the multiplicity of specific forms, the Trilobites are far from possessing so marked a predominance. * * Although the Trilobites maintain *some* numerical superiority, as regards species, in all the three faunas, it has not been very noticeable. But, if we consider only the second and third faunas, the predominance of the Cephalopods becomes, on the contrary, very great. On the whole, in spite of the privileges which seem to assure the first rank to the Trilobites, in the whole of the Silurian faunas, the Cephalopods possess exclusively certain advantages, which assured their domination during the continuance of the second and third faunas. The total number of Silurian species enumerated in the "Thesaurus Siluricus," in 1868, reached 9,030. Adding about 800 Bohemian species, the names of which are not yet published, and the new species announced in Canada and elsewhere, the sum total of forms known in the Silurian formation may be accounted as 10,000, in round numbers. The Trilobites contribute to this sum in the proportion of 0·167. and the Cephalopods in that of 0·162. The difference is hardly sensible.

II. *First appearance of Cephalopods.*—What is most inexplicable to us is the relative abruptness with which the Cephalopods seem to manifest themselves at the same time in many countries, under very various generic and specific forms, toward the beginning of the second fauna, while their remains have not been found in the Primordial fauna. Considering the Silurian countries as a whole, the types which show themselves in these first appearances are 12 in number, and so represent very nearly half the total number of types of this order, which is 25. * * These 12 types, as a whole, present the principal forms of the shell * * from the straight form of *Orthoceras* to the completely rolled-up forms of *Nautilus* and *Trochoceras*. While the greater part of them show the simple opening which characterizes our first series, one of them, *Gomphoceras*, represents,

by its completely contracted aperture, the more ancient form corresponding with our second series. Still, we observe one important deficiency, namely, the t al absence of the more simple forms of the order, *i. e.*, the *oceratidæ*. The number of species derived from these 12 pri itive types is about 165. * * This number represents about one-third of the 478 forms which characterize the second fauna in all Silurian countries. Thus, the order shows itself already largely developed, in generic types and specific forms, upon the horizons where we observe the most ancient traces of its existence. We ought also to note the important fact that, during the first epoch, the number of migrating species, or those common to many countries upon the grand northern zone of Europe and America, does not constitute one-fourth of the sum total of existing forms. There is, moreover, no form common to these northern regions and to the grand central zone of Europe. Consequently, the autochthonous species, *i. e.*, those belonging exclusively to a single country, represent more than three-fourths of the sum indicated, viz: 165. This localization of the great majority of the species, at a time so remote as the beginning of the second fauna, is so much the more worthy of attention, since the Cephalopods, as pelagic Mollusks, are supposed to enjoy great powers of locomotion. Moreover, science being brought to admit the existence of a very nearly uniform temperature, over the globe, at this epoch, one of the great obstacles to the general diffusion of these Mollusks can not be invoked to explain their distribution in so many centers distinct in their local faunas. The apparent abruptness in their first development, and the localization in their horizontal distribution, do not constitute exceptions which are anomalous and peculiar to this order. On the contrary, it seems to us that these are habitual and normal phenomena, which manifest themselves in the mode of appearance of the orders or of the principal families composing the Paleozoic fauna.

We possess another striking example in the Silurian Crustaceans. In all countries where the Primordial fauna has been observed, numerous generic and specific forms of Trilobites start together. While some of the first genera of this tribe are found in most countries, each of these, and especially each of the great zones, possesses many contemporaneous types which exclusively belong to it. But it is especially the distribution of specific forms which offers us one of the most remarkable examples of localization. In fact, among more than 240 species already known in the whole of the Primordial fauna properly so called, the number of those which are common to two countries geographically separated is very small. Thus the circumstances which seemed the most inexplicable, in the first appearance of the

Cephalopods, were already previously manifested in the first appearance of the Trilobites. They seem to have been even more exaggerated in what concerns this tribe of Crustaceans. We are far from believing that these appearances are due solely to the disappearance of lost faunas. On the contrary, we have demonstrated that this hypothetical conception can by no means be applied to the Cephalopods. We would here call attention to a very important fact, and one which shows a new harmony between the appearance of the Cephalopods and that of the Trilobites. We proved, in 1852, that all the genera of Trilobites appeared during the Silurian, excepting a doubtful form, called *Griffithides*. We now perceive, also, that all the generic types of the [Paleozoic] Cephalopods, *i. e.*, of the Goniatidæ, the Nautilidæ and the Ascoceratidæ, have had their rise during the same age. As to the exclusively Devonian species, named *Clymenia*, they merely represent the endogastric form of the type, of which the *Goniatites* constitute the corresponding exogastric form. Thus the first appearances of all the district types of Trilobites and Cephalopods, with which we are dealing, have been alike concentrated in the Silurian and have been accompanied by like circumstances. These circumstances, then, seem to us to be normal.

III. *Evolution of Cephalopods.*—The evolution of Cephalopods, during the continuance of the second and third Silurian fauna, is very irregular, in each of the countries, in each of the grand zones, and also in the entire Silurian world. * * * To the absolute maximum of 665 species, produced by 10 types, in our band e^2, succeeds immediately the absolute minimum of 2 genera and the small number of 31 species, in our band f^1. By contrast, to the absolute minimum of 12 species, produced by 3 genera, in our band g^2, succeeds immediately the absolute maximum of 11 types, represented only by 86 species, in our band g^3. These two facts, well ascertained, suffice to show us that we should not attribute the evolution of the Cephalopods to the simple theoretical law of descent (*filiation*) and of slow transformation. It is important to remark that, in certain regions, the existence of Cephalopods seems to be interrupted by some total intermissions, *i. e.*, by the absence of every vestige of this order, in more or less considerable vertical thicknesses of the formations. We have noted such total intermissions in different countries; viz: 2 in Bohemia, 1 in Canada, 3 in New York, 1 in Wisconsin and 1 in Illinois. We have also shown, at the same time, that the local repeopling can not be attributed solely to immigrations, and that it consists principally of new species, peculiar to each country. * * *

The appearances of the 25 types of this order are mainly concentrated in three principal epochs, which correspond to the

beginning of the second fauna, the beginning of the third fauna, and the end of the third fauna. We observe, also, that these three epochs are at the same time distinguished by the co-existence of greater numbers of genera, *i. e.*, that they present three nearly equal *maxima*, viz: 12 types to each of the first two epochs and only 11 to the third. On the contrary, the epoch which corresponds with the end of the second fauna presents only 8 co-existing types; and again we find only 8 about the middle of the second fauna; while about the middle of the third fauna we can count only 4 or 5. We do not know any reason to be assigned for these fluctuations. They are particularly well marked in the basin of Bohemia, doubtless on account of its great richness. * * About the beginning of the third fauna, the 12 existing types show a development of specific forms which constitute the absolute maximum of all the Silurian, viz, about 1000 species. This is principally due to the contribution furnished by Bohemia, viz: 746 species.

IV. *Parallel between the chronological and zoölogical evolution of Cephalopods.*—Concordance between geological and zoölogical evolution should be plainly shown, if the more simple forms of zoölogical evolution had appeared first, and if, on the other hand, the more complicated forms had appeared last, in the series of Silurian epochs. Now, observations of facts shows us that precisely the contrary has occurred. In fact, according to existing documents, the more simple forms, viz: the *Ascoceratidæ*, appeared only toward the end of the second fauna in Canada, and at the beginning of the third fauna in Bohemia. On the other hand, the more complex forms, such as *Nautilus* and *Trochoceras*, are manifested from the beginning of the second fauna, in America. * * These facts suffice to show us the irreconcilable discordance which exists between the zoölogical and the chronological evolution of Silurian Cephalopods.

But we have also noted, in the course of our studies, other facts, which confirm this discordance, and which are inexplicable by the transformation theory. The principal ones are as follows: 1. The almost abrupt appearance of a great number of generic types of all shapes, disseminated through different Silurian regions, about the beginning of the second fauna, does not accord with the idea of their slow and successive derivation from any earlier prototype whatever. In fact we have shown that the total absence of Cephalopods from the Primordial Silurian fauna forbids our supposing that these types were developed during the existence of a series of ante-primordial faunas, of which no trace remains. 2. The slow transformations, conceived of theoretically, would not account for the extraordinary accumulation of specific forms which is found in Bohemia, within a very narrow horizontal area, and the

vertical thickness of a few calcareous layers of our formation E. These distinct forms reach the number of 746, representing the proportion of 0·46, *i. e.*, nearly half, of the 1622 species of Cephalopods to-day known in the Silurian world. 3. If the transformations and divergence of specific forms results, as theory indicates, in the production of new types, we ought especially to observe traces of this phenomenon in Bohemia, as a consequence of the coëxistence of 10 generic types and 665 specific forms, during the deposition of our limestone bed e^2. Now, we have before shown that the sum of all the variations which one might have expected here, according to theory, has *really* resulted in the *disappearance* of 8 types and 644 species, while 2 types and 21 species are continued in the equally calcareous overlying band f^1. Lest anyone should wish to consider this as constituting a purely local exception, resulting from accidental causes which acted in spite of time and place, we will mention another of the same character, and free from any similar interpretation. We have before stated that, among the families of Cephalopods which are the object of our present study, there has arisen no new type, either cosmopolite or local, during all the continuance of the Devonian, Carboniferous and Permian faunas. * * Still, as a whole, these faunas present a number of species of Cephalopods at least as considerable as that of the second Silurian fauna, during which there appeared 17 generic types. In this case, neither time, nor space, nor the number of specific forms, failed to favor the production of some new type.

It is then the very power of variation or transformation that has itself been wanting. If this pretended force really has a continuous action, and one inherent to the nature of organized beings, why was it so suddenly and for so long a time paralyzed as to its effect upon the propagation of the families which have from the beginning constituted the most powerful order of Mollusks? This same paralysis has been prolonged up to the present time in the *Nautili*, which have enjoyed the rare privilege of an existence without any other limits than those of the geological ages and the terrestrial surface. In fact, they have maintained their primitive generic characters, from the Silurian period, without producing a single collateral and distinct type, in spite of the number of their specific forms, in every country and in each of the extinct faunas. If the type of Cephalopods * * had been gradually constituted by transformations, up to their normal form, the intermediate transitions would be represented by a multitude of individuals, whose number might well surpass that of the examples showing the exact form which we find. Now, these transition forms are nowhere found in Silurian countries. On

the contrary, wherever we observe the first appearance of a type, the conformation of the shell offers to us all the characters which distinguish it from other types of this order. No country seems to us to have been more favorable than Bohemia for the preservation of transition forms between the 20 types which it possesses; for many of them are represented by myriads of individuals, among which we do not discover any intermediate form. Of certain species, * * we have been able to collect series of individuals representing all ages of the shell, from the embryo to the adult. Since these forms, really intermediate in the development of a species, are so well preserved, why have the hypothetically intermediate forms between the types invariably disappeared, in the same basin and the same limestone layers?

In view of these facts, which are reproduced in an analogous manner in all countries, it is probable that no scientist would risk putting forth the assertion that the formations including the forms intermediate between our 25 types of Cephalopods have been everywhere invariably destroyed by denudations. It would then be superfluous to refute such a supposition. Still, we would observe that the very rocks which have been removed by denuding agents, have left vestiges of their existence and their faunas. Thus, the *diluvium* of the north of Germany has already furnished 47 species of Cephalopods * * which comes from the denuded rocks of Scandinavia and Russia. No one of these species presents to us a form intermediate between the types of these countries. Further, the pebbles of Budleigh-Salterton, in Devonshire, have already yielded, according to a recent private communication from Mr. Thos. Davidson, more than 80 species, of different orders, derived in part from still unknown outcrops of Silurian and Devonian rocks, without the appearance among them of any forms transitional between established types. So, in any case, the disappearance of deposits inclosing forms intermediate between the 25 normal types of Cephalopods would be completely inadmissible in science. We could not then invoke it in order to account for the invariable absence of these forms in the Silurian formations. On the contrary, all observations concur in indicating to us that these forms have never existed. We ought further to remark that the small number of forms which can be considered as showing an apparent transition, between any two normal types whatever, have hitherto been reported only upon horizons when their existence constitutes the gravest anachronism as regards supposed transformations. * * * These intermediate forms are posterior to the normal type, while, according to theory, they ought to be anterior to it. * * The *Endocerata* noted in our studies upon the evolution of the Cephalopods, as offering ideally an intermediate type between

Ascoceras and *Orthoceras*, appeared toward the origin of the second fauna, while *Ascoceras* is known only toward the end of this fauna. If we admit the reality of the transition between these forms, it will be necessary also to admit that this has taken place from the more composite forms, *Orthoceras*, to the more simple, *Ascoceras*, *i. e.*, following an order diametrically opposed to that which theory supposes.

In short, not only is the chronological evolution of Cephalopods in full discordance with their zoölogical evolution, but, also, the various considerations set forth concur in demonstrating that the suppositions relative to transformations vanish before observed facts, in all countries. On the contrary, these facts all tend * * to inspire the belief that the types of Cephalopods have appeared [originally] under the characteristic and normal forms by which we distinguish them. They seem, then, to owe their origin to a special cause and one totally distinct from descent from anterior forms.

* * * * * * *

VII. *Extinction and gradual renovation of specific forms.*—All geologists have remarked that most of the species which characterize a formation disappear between its vertical limits, and are replaced by new forms which similarly characterize the following formation. * * * It is clear that species which cannot be attributed to either of these three sources [1, vertical propagation of identical species; 2, descent from anterior species; 3, immigration of foreign species] are entirely new, and represent the effect of gradual renewal. These three sources united have furnished only about 34 per cent. of the species of Cephalopods in any fauna whatever. * * There remain, then, about 66 per cent. of new species, representing the influence of gradual renewal in each distinct fauna. In every case, renovation or the gradual and successive appearance of new forms seems to have itself contributed at least as much as, and probably much more than, all other apparent sources, to furnish the elements of the successive faunas of Cephalopods, during the Silurian age.

It remains for us to call the attention of our scientific readers to the harmony which exists between the results of this study upon the gradual renewal of species and the results of the parallel established above between the zoölogical and the chronological evolution of Cephalopods. In considering the chronological order of the appearance of types, this parallel has brought us to recognize that the generic and specific forms of the Silurian Cephalopods cannot be regarded as gradually derived from each other by an insensible passage from the more simple to the more complicated forms. Consequently, the successive evolution of the Cephalopods cannot be attri-

buted to a power of variation inherent in their nature and only controlled by the influence of the surrounding medium. According to this conclusion, it is indispensable to recur to other causes, in order to account for the successive appearance of the forms of this order. Now, in our study upon gradual renovation, in analyzing the elements of diverse origin which constitute any fauna whatever of Cephalopods, we have shown that at each of the epochs characterized by a distinct fauna, some new and independent forms, representing at least half of the coëxisting species, are made manifest without appreciable cause, and as if by the effect of a special creation, in each of the Silurian countries. This conclusion, immediately deduced from the whole of the facts observed in the Silurian world, confirms, in a manifest manner, our preceding conclusion, derived from the parallel between the zoölogical and the chronological evolution of Cephalopods. Both contribute equally to show us how far teachings founded upon positive facts determined by science are in discordance with the spontaneous intuitions of any theories whatever.

Mr. Barrande enumerates in his list of Silurian Cephalopods 25 genera and 1622 species.

In the volume on Trilobites, mentioned at the head of our article, he gives us the results of similar studies upon the Trilobites, and from this point reaches conclusions in accordance with those drawn from the study of the Cephalopods. We have room for merely his closing summary.

"Upon one of the earlier pages of this volume, we have recalled the fact that direct observation has marvelously confirmed the previsions of astronomical theories on the subject of the planet Neptune. These theories are then in harmony with the truth. By way of contrast, we should state, as the final result of our studies, that direct observation radically contradicts all the previsions of paleontological theories on the subject of the composition of the earlier phases of the Primordial Silurian fauna. In short, the special study of each of the zoölogical elements which constitute these phases has demonstrated to us that the theoretical previsions are in complete discord with the observed facts of paleontology. These discordances are so numerous and so well marked, that the composition of the real fauna would seem to have been calculated for the express purpose of contradicting all that the theories teach us regarding the first appearance and the primitive evolution of the forms of animal life upon the globe. So, the paleontological theories are completely invalidated by reality, whose test they cannot sustain. It is still to be ascertained whether the demonstrated discordances ought to be imputed solely to the essential principle of the theories of descent and

transformation, or whether they are derived, to some extent, from their point of departure in paleontology, *i. e.*, from the supposed animal nature of *Eozoon*. This is a question whose solutions we leave to those whom it concerns. For our own part, we persist in thinking that science ought to keep strictly within the sphere of observed facts, and remain completely independent of every theory which may tend to lead it into the sphere of imagination."

ART. XXVI.—*On the Red Oxide of Zinc of New Jersey;* by AUG. A. HAYES, A.A.S.

THIS mineral, discovered and analysed by the late Dr. Bruce of New York, was subsequently examined by M. Berthier. In his "Traité des Essais par la voie Sèche," 1834, are his results, in which no allusion to the cause of the rich red color of this mineral is made, but the remark, "le manganèse y est probablement à l'état de deutoxide," closes the description.

In the year 1845 I made some analyses of this beautiful mineral for my late friend, Mr. Frank Alger, who was then compiling a treatise on mineralogy. Impressed by its interesting relations to light, the experiments and observations were multiplied, and resulted in the expression of the opinion, that the red color is due to the presence in the mineral of extremely brilliant scales of specular iron, which, transmitting a red-brown color, and reflecting lighter tints, acted as a most powerful coloring matter would do. It was also demonstrated that no oxide of manganese higher than protoxide existed in various samples. This opinion in relation to the cause of the coloration was adopted by Mr. Alger, and expressed in his published work, and subsequently Prof. Dana quoted the analysis and opinion in his standard work on Mineralogy. In the years, since passed, the subject has been several times discussed by scientific friends; and when doubts of the sufficiency of the cause have been expressed, a resort to ocular proofs at the moment has been deemed convincing and satisfactory.

On turning to the description of this mineral in the 5th Edition of the admirable system of Mineralogy by Prof. Dana, I was surprised by the statement that the distinguished and accurate author had found, by "means of a high magnifying power, that this ore is free from foreign scales of red oxide of iron."

Dr. Lewis Feuchtwanger had kindly sent me a large cabinet specimen of a finely colored mass of this mineral engaged in calcite. At some points of junction the red oxide seemed to

have stained the white calcite, as a coloring matter would have done. This,—with various specimens of my own, including part of the most distinctly crystallized form yet found, and ranging in color from deep red garnet to reddish-orange—were selected as the subjects enabling me to criticise my early results, with the light afforded by improved methods of research. To those who turn over these pages, it may sum a trivial matter whether the color of this mineral be due to "red oxide of manganese" or another kind of matter, so long as a body foreign to the basis oxide of zinc is present. I do not accept this conclusion.

If we are to seek a complete knowledge of a mineral presenting color or altering white light—the cause of this color, or action on light, becomes an important part of it. Color may arise from modification of structure, by the intrusion of unallied minerals; by quantity of added matter or solely by the action of a minute weight of a body so framed as to decompose light. These are proper subjects for study, and the results become, not only an advance in science, but afford to the student the delight arising from positive increase of knowledge, and an introduction to a large untrodden field—open to research.

The color of the amethyst is due to little flaws and cavities filled with a highly refracting coloring matter. This fact has been known for about a century. In a quartz crystal examined a part of the length was colorless; then a section of amethyst was followed by colorless quartz—the summit of the crystal was amethyst—and no preceptible disturbance of the crystal-forming process could be detected.

In this case, the beauty, value and interest in the colored part of the same crystal were greatly increased by a minute amount of added matter, and the suggestions arising from states of altered conditions. The "Oriental" amethyst of the dealers is distinguished from other kinds only by the number and dispositions of these color flaws, a fact which has surprised and interested every lapidary and collector, when the proofs were offered. The remark applies to colored gems—as we see commonly in emerald when compared with the same mineral as aqua-marine, and in all collections of lapidaries, museums and of private owners in Europe: it is easy to convince one's self that the more valued qualities in colored gems are always due to defects of a certain magnitude in the crystal, which have been filled and changed by the intrusion of foreign mineral bodies, conferring more and new beauty, and enhancing the intrinsic value of the gem.

The observations which follow apply to the mineral which has been freed from carbonates and crenates, and dried at 100° C.

This mineral presents a crystalline form in lamina of varied thickness, sometimes distinctly divided by thin layers of specular iron scales. These scales when abundant reflect an iron-black color from the surface, while the cross fracture is ruby-colored. As the depth and beauty of the color diminishes, the scales of specular iron, whether observed in the mass, or separated by solution, become less abundant, and Prof. Blake has described a yellow specimen free from iron scales. The powder is of some shade of orange-yellow: the semi-transparent and rich red fragments of this mineral when looked *upon* become opaque when placed between the eye and some source of light. The rays of light enter the mass, and absorption of part takes place, while parts are being refracted and reflected. Entire transmission of red rays does not occur; in thin splinters only a little altered light passes. We thus get an indication of unequally diffused foreign matter, not pertaining to, or necessary in, the structure of the mineral. In using either the Nachet or chemical form of microscope, the aid of the lowest or lower power is best; and when both reflected and transmitted daylight illuminates the assay, we observe that a splinter of the mineral transmits an olive-green or brownish-yellow light, varying with the thickness. Thick portions reflect a portion of reddish light, in shadow, olive to bluish-gray, becoming silvery in slant rays. At about 20° inclination a splinter in partly reflected light becomes crossed by lines of a dark color. Artificial light makes the assay more yellow; a nice adjustment of the incident ray allows a red reflection from the lines, now become surfaces of reflection. If the assay be cubical, the rays transmitted *through* the lamina are arrested and dispersed, when the ends or sides of the cubes are observed. In these directions dark-colored scales may be seen engaged in the brownish-yellow or olive-tinted masses. This observation is important in explanation of diversity of conclusions among observers. The scales generally lie parallel with the laminæ of the assay, so that the passing rays are transmitted or slightly disturbed, and the red color of the mineral is replaced by that color, which the scales transmit in a colorless medium. If a concentrated fluid sulphate of the ore be observed, the naked eye takes in the same tint.

The tendency of fracture is in the direction of the laminæ, and in preparing the assays the better way is to crush the mineral between steel surfaces to the diameter of pin wire, and select the more opaque grains. These show the scales as distinctly as the bars of a window are seen.

Fragments of larger size may be covered with acetic hydrate (No. 8 of the shops). The assay dissolves as quietly as would sugar, and the line of contact of assay with acid never shows a dilution of color. Points of scales, having right-lined forms, appear, and can be moved so as to transmit or reflect colored light. But the most beautiful exhibition occurs later. The strength of the acid is such as to form a saturated solution, and hence it acts most rapidly on the more basic elements of the ore, and in so doing allows the foreign bodies only slightly altered to come in view. From the scales, little clouds arise and float away, often carrying the specular iron scales, and decomposing light. In this way, beautiful hues accompany the chemical and mechanical actions, and the latter show the constitution and compound nature of these scales.

Sulphuric hydrate, so diluted as to form the brilliant transparent rhombic prisms of zinc-sulphate, in acting on the assay in a saturated solution, transfers the scales in the assay to the colorless crystals forming. We get the scales of specular iron arranged in the axes of the prisms of little crystals; but the charms of color, luster and action on light are so far lost, that the ordinary exhibition of translucent scales engaged in a transparent medium alone is given.

The facts, that the red zinc ore always contains particles of specular iron of scale thickness, bounded by right lines, and that these scales are covered by or connected with a highly lustrous mineral, decomposed by the feeblest acids, become evident. That the color of this ore is not produced by any inhering coloring matter, but results from the action of intruding minerals absorbing some, reflecting and dispersing other rays of light, can be proved by the aid of the microscope.

In passing to the chemical analyses of this mineral, it becomes my duty to meet some suppositions formed by others respecting the cause of color; to prove, so far as is possible for me, the *negative* in relation to any other cause than that which a course of experiments demonstrates as existing. The sufficiency of this cause in producing the effect may not be convincing alike to differently constituted minds. It was a casual remark of Berthier,—a most distinguished and accurate chemist—that the oxide of manganese in this mineral is probably in the state of deutoxide. This *probability* has been seized upon to account for the color of the mineral. There is no red compound of deutoxide of manganese known which could exist in this mineral. Compounds with sulphuric hydrate and chlorine exist, but I make use of both these re-agents as most sensitive and trustworthy in proving the absence of any oxide of manganese higher than protoxide.

Composition. Retaining the numbers obtained in 1845, after

most carefully criticising their accuracy, as representing the composition of the more perfect red specimens, we have

Zinc protoxide	93·48
Manganese protoxide	5·50
Scales of specular iron	0·44
Ferric deutoxide	0·36
Loss	0·22

The loss is excessive, and was then supposed to arise from a body undetermined. Resort to the more precise mode of independent separation did not diminish this loss, and samples reserved have enabled me to account for it in part, and add silica, calcium oxide and another metal to the number of those before known to be present. In resuming this subject, the ore has been subjected to a careful search for all other known bodies which can be detected without the aid of the spectroscope. The red samples of this ore may be considered as a mixture of pure anhydrous zinc and manganous oxides in ninety-nine parts, and foreign intrusive bodies one part in one hundred parts, and in some cases the latter do not form half this weight; making the one hundredth part scales of specular iron, ferric deutoxide, silica, molybdous oxide, calcic oxide and HO, which have been determined.

The absence of the higher oxides of manganese was proved by the fact that the clean mineral of more than four pounds weight, when tested in pure chlorhydric acid, did not produce chlorine.* When the ore, chlorhydric acid and slips of copper are inclosed, the acid dissolves only so much copper as the deutoxide of iron present would do. When coarse powder of the ore is added to strong chlorhydric acid, no color appears near the particles,—a most sensitive test. Avoiding any reaction of the mass of zinc oxide—the latter separated from the residue by cold diluted acids, such as acetic hydrate and sulphuric hydrate, which do not dissolve higher oxides of manganese—these residues do not afford any traces of the higher oxides, where, if they existed in this ore, they would be concentrated. If the mineral has been heated in the steps of analysis, or weathered by exposure, then deutoxide of manganese appears, and hence doubtless the supposition of its occurrence has arisen.

If we suspend large fragments of prepared ore in diluted sulphuric hydrate contained in a tall jar, the descending striæ of the solution forming contain scales of specular iron, from which the brilliant investing matter has been dissolved. Removing and drying the fragments, after partial solution, the saline

* When the preparation of pure chlorhydric acid was going on, it was observed that chlorine and sulphurous acid may co-exist for weeks in the stronger solutions of this acid without re-action.

matter incrusts the surface of an olive-yellow hue. The numerous points projecting permit us to see the arrangement of the altered scales, and in a beam of light to catch the absorption, reflections and dispersion caused by the unaltered mineral within the fragments. This observation is suggestive in several ways. In the instances of the lightest colored specimens being used in the trials, it was necessary to view the striæ through a lens, in order to see the scales descending, although the collection at the bottom of the jar proved their presence. This led me to inclose the clean fragments of ore in four, six and eight thicknesses of fine cambric, which had been so treated as to leave nearly pure cellulose. The cylindrical rolls were suspended in tall jars of acetic and sulphuric hydrate—largely diluted—so as to be just below the line of surface. Descending striæ indicated the chemical action as before, and after two or three days the rolls were removed, soaked in successive portions of water, and opened. The inner surface of the roll was covered with a lustrous film, composed of transparent scaly particles of a general light brown color, highly reflective and in part transparent. The siliceous skeleton and partly decomposed mineral connected with the iron scales was thus obtained. When the solutions from the rolls had reposed for eight days, a ray of light showed myriads of diffused and nacreous scales in the solution, proving their excessive fineness and tenuity.

This ore is so eminently basic that it dissolves in all the solvents of even zinc hydrate, and in the act often develops heat. In my endeavors to select a solvent which, removing most of the zinc and manganous oxides, would leave the intruded mineral free, all the solvents which suggested themselves have been tried in this connection without success. The crystallizing process has also been tried, and even the beautiful and neatly crystallizing double zinc and manganous and ammonium sulphate retained portions of the mineral, after graduated crystallization. The best and most instructive mode of action adopted is the following:

Both ammonium chloride and hydrate dissolve the ore, and in the air the manganous deutoxide forms and separates. If we pass hydrogen gas though a solution of the ore, from which scales of specular iron and silica have been separated, contained in a two-tubulated flask, ammonia chloride and hydrate in excess being added, the oxides first precipitated dissolve. After repose, the clear solution may be removed by pressure of the gas, leaving a mere flock of ferric deutoxide. If silica is present it dissolves in the zinc solution with the other bodies, and it may be stated here that the substances sought for are so small a part of the whole weight that, in presence of the mass of zinc oxide, re-agents generally fail in separating them. By placing

fragments of ore of one-third of an inch cube in cambric cellulose as above stated, and using as a solvent the ammonia chloride and hydrate solution in the jars, the ore dissolves freely, while the surface of the solution, and later the outer folds of the rolls become covered with the manganic deutoxide, formed from the protoxide as it is withdrawn from the protoxide solution below. This action alone would settle the condition of the manganese existing in the ore; but it also removes both zinc and manganous oxides from the mineral. As oxygen cannot penetrate the folds through a manganous solution, after the action has ceased we have left on the inner fold the intrusive mineral, brilliant, satin-like in luster, and in the most perfect state it has presented. It has, however, been partially decomposed, and is a skeleton or silhouette of the original, greatly expanded, excepting just where it is engaged in undissolved portions of the fragments.

Thus obtained, its general hue is brown, by reflected light, as we see it by the microscope in the mineral; but its micaceous films transmit white and yellowish rays, excepting when engaging scales of specular iron; then reddish-brown to orange-red rays are transmitted, and the reflections become lustrous in a high degree.*

The production of color by this intrusive mineral, which may be considered as a silicate of zinc, calcium and ferric deutoxide, seems to depend on its mica-like structure and compound composition, including the specular iron scales. We have seen that the ore loses its red color when a ray of light is transmitted, or only the brown color of these scales comes in view, and where partial absorption succeeds red color results.

The experiments demonstrating its constant presence in the colored specimens of ore, and its proportions following the depth of color always, would not be conclusive, if they failed to throw light on the state of division naturally presented. Here the value of the observations of the solution of the mineral in close textures rests. Even when we use nearly pure cellulose paper-filters of finest texture, and many folds, the mineral passes, and we reach that state of division, where mordants dye solid colors, or the mystic boundary separating solution proper from suspension. The apparent staining of the calcite by the ore alluded to is here explained, and the necessity for the existence of much ponderable matter to produce color, even in the powder, negatived. Indeed, in some reddish-colored samples, the whole foreign matter separated did not exced $\frac{1}{1000}$th part, and only a small part of this was color-producing material.

* It is not, perhaps, generally known that the splendid peacock hues of the anthracite coal of Pennsylvania, in the upper layers, are due to the decomposition of light by the films of calcite, formed from calcium crenate as in Newtonian rings.

Although multiplied trials have failed in separating the intrusive mineral, in a pure state, we have the evidence of its extraordinary power of action on light, in its partially decomposed condition, and in some trials we can see it naturally engaged in the mass, and coloring it, while its appearance at the surface under chemical action removes all doubt of its being the cause of color. It was deemed important that the feature of sufficiency of this cause of color should be supported by analogy, and I have sought in several directions for facts of this kind. I submit one of these.

The mineral carnallite presents in some specimens a full rich red color. By fracturing and selection samples were made for analysis.

1200 parts in pure water afforded one part of matter remaining from a colorless, clear solution. This one part afforded $\frac{4}{100}$th part of specular iron scales tolerably pure, while the brilliant satin-like investing mineral, in proportion too small for weighing, gave to the compound a resemblance to the luster color, and action on light, seen in the intruding mineral of the red oxide of zinc. This is the most significant proof I have met with, and the work was done before the interesting experiments of Prof. G. Rose were published in this country.

In numerous trials no feature favoring the presence of other causes of color has been observed, and this ore must take its place with other minerals whose colors are due to foreign minerals crystallizing with or intruding into them.

The detection of molybdenum in this ore is easily effected by evaporating a neutral chlorhydric solution to a syrupy consistence on a hasp formed of zinc and platinum. The platinum becomes black and covered with a coating, which dissolves in potassium bisulphate, or phosphoric hydrate as altered by heat, in a state fitted for testing.

Brookline, Mass., 10th July, 1872.

ART. XXVII.—*Remarks on Dr. R. Radau's paper in Dr. Carl's "Repertorium"* (vol. viii., no. 1), *entitled "Remarks on the influence of a motion of Translation of a Sounding Body on the Pitch of the Sound;"* by ALFRED M. MAYER, Ph.D.

IN the last number of *Carl's Repertorium*, Dr. R. Radau, of Paris, writes an article, bearing the above heading, of which the following is the opening paragraph:

"The simplest means of showing the influence of a motion of the source of sound on the apparent pitch, an effect first suspected by Doppler, is, perhaps, the application of two tuning

forks of almost equal pitch. This is already mentioned in König's Catalogue of Acoustic Apparatus, 1865; also in Pisko's Latest Acoustical Apparatus, page 224; and in my Popular Acoustics (page 298 of the German edition), as also in other places. Still one Mr. A. M. Mayer has communicated the same method to the Paris Academy of Sciences, 11th March, as something altogether new. The only difference is this: that König counts the beats which are gained or lost to the ear by a motion of the tuning fork, whereby the change of pitch is measured, while Mr. Mayer, an American, only shows by a little cork ball, resting against the stationary fork, whether it vibrates or not with the moving one."

As Dr. Radau does not give König's experiments and mine, so that they may be compared, but quickly disposes of us both to hurry to tell of his own, I deem it but just to König and to myself that our experiments should be set forth in our own words, so that a just inference may be drawn from their comparison, while, at the same time, they will serve one to form a proper estimate of M. Radau's claim to experiments subsequently explained in his paper.

From König's *Catalogue des Appareils d'Acoustique*, Paris, 1865, p. 16: "73. Deux diapasons ut_4, montés sur leurs caisses de résonnances et accordés pour donner exactement quatre battements par seconde.

On peut varier l'expérience de plusieurs manières. Voici la plus simple.

On met les deux diapasons l'un à côté de l'autre, à quelque distance de l'oreille; puis, ayant constaté d'abord qu'ils donnent bien les quatre battements par seconde, on rapproche le plus grave des deux de l'oreille, d'environ 60 centimètres, tout en continuant de compter les battements. L'oreille reçoit alors de ce diapason une vibration double de plus, pendant le temps employé à le déplacer, et l'on constate alors la perte d'un battement dans le même temps. Si c'est le plus aigu des deux diapasons que l'on rapproche de l'oreille, on obtient un battement de plus.

Si on tient l'un des diapasons à la main, les yeux fixés sur un pendule qui bat les secondes, on arrive sans peine à lui donner un mouvement de va-et-vient, tel qu'on entende toujours alternativement trois et cinq battements par seconde. J'ai enfin fait l'expérience en mettant les deux diapasons à une certaine distance l'un de l'autre, et en promenant entre eux, soit l'oreille elle-même, soit ce qui est de beaucoup préférable, un résonnateur ut_4, mis en communication avec l'oreille par un tube en caoutchouc.

Je ferai encore observer qu'on arrive, par le même procéde, à déterminer approximativement la longueur d'onde d'un son et sa hauteur."

From the *Comptes Rendus*, 11 Mars, 1872: "*Expériences acoustiques tendant à démontrer que la translation d'un corps en vibration donne lieu à une onde d'une longueur différente de celle que produit le même corps vibrant dans une position fixe.* Note de M. A. M. Mayer, présentée par M. Delaunay.

L'APPAREIL.

"Après m'être procuré quatre diapasons à fourchette appuyés sur des caisses résonnantes et donnant la note $ut_3=256$ vibrations complètes par seconde, je les ai designés par les nos. 1, 2, 3, 4. J'ai mis à l'unisson parfait les nos. 1 et 2 d'après un procédé que j'indiquerai plus tard. No. 1 fut placé devant une lanterne magique; une petite balle de bon liége (6 millimètres de diamètre), suspendue par un filament de soie, affleurait une de ses branches; l'image du diapason et de la balle de liége fut projetée sur un écran. No. 3 avait l'extrémité d'une de ses branches chargée de cire, de manière à donner deux battements par seconde avec no. 1 ou no. 2.

No. 4 avait les extrémités de ses branches limées et donnait aussi deux battements par seconde avec no. 1 ou no. 2; ainsi no. 4 faisait deux vibrations par seconde de plus que no. 1, tandis que no. 3 faisait deux vibrations par seconde de moins que no. 1.

LES EXPÉRIENCES.

"Dans les expériences 1 à 7 inclusivement, le diapason no. 1 reste devant la lanterne, la balle de liége affleurant une de ses branches.

EXP. 1.—Diapason no. 2, attaché à sa caisse et tenu à la main, est mis en vibration à une distance de 30 et 60 pieds du no. 1; la balle est écartée de la branche du diapason no. 1 qui vibre à l'unisson avec no. 2.

EXP. 2.—Je me suis placé à une distance de 30 pieds du no. 1, tenant le diapason no. 2 détaché dans une main et sa caisse dans l'autre. Alors, j'ai fait vibrer le diapason et je me suis dirigé rapidement vers no. 1. Lorsque mon movement fut devenu uniforme, je posai le diapason sur sa caisse, et l'ôtai avant de m'arrêter. Bien que je n'aie été éloigné du diapason no. 1 que d'un pied à peu près, la balle de liége resta en contact avec la branche du diapason.

EXP. 3.—Je me suis approché de nouveau du diapason no. 1 comme dans l'expérience 2, mais sans ôter le diapason de sa caisse après l'avoir attaché. La balle ne bougea pas jusqu'au moment où je m'arrêtai; mais à ce moment même mon assistant, qui tenait l'oreille près de la caisse tandis qu'il observait l'écran, entendit vibrer le diapason no. 1 et vit sauter la balle de liége.

Exp. 4 et 5.—Je me suis éloigné du diapason no. 1 au lieu de m'en approcher. Le résultat a été le même que dans les exp. 2 et 3.

Exp. 6.—J'ai fait vibrer, comme dans l'exp. 1, le diapason no. 3, qui faisait 254 vibrations par seconde. La balle ne bougea point. Alors j'ai détaché le diapason de sa caisse, et, me mettant à une distance de 30 pieds du diapason no. 1, j'ai balancé la caisse dans la main vers no. 1, mettant no. 3 dessus quand elle approchait no. 1 avec la vitesse convenable (8—9 pieds par seconde). La balle fut subitement rejetée de no. 1. Si l'on ralentit ou accélère considérablement le mouvement de va-et-vient de la caisse, les vibrations de no. 3 ne produiront aucun effet sur no. 1.

Exp. 7.—Le diapason no. 4, qui fait deux vibrations par seconde de plus que no. 1, fut substitué à celui employé dans l'exp. 6, mais placé sur la caisse en mouvement, quand celle-ci s'éloignait de no. 1. Le résultat de ce mouvement et des changements effectués dans la vitesse fut le même que dans l'exp. 6.

Exp. 8.—J'ai placé le diapason no. 3 devant la lanterne et balancé le no. 1 comme dans l'exp. 7, avec le même résultat.

Exp. 9.—J'ai placé le diapason no. 4 devant la lanterne et balancé le no. 1 comme dans l'exp. 6. Le résultat fut le même que dans l'exp. 6."

It is thus seen that König's method is founded on *the phenomenon of beats*, and his experiments are adapted only for exhibition before a small auditory; while my method is founded on *the phenomenon of the communication of vibrations*, and as the images of the fork and cork-ball are projected in greatly magnified proportions on a screen, they have been witnessed, with entire satisfaction, by an audience of nearly one thousand persons. In other words, König's are, we may say, *subjective* in their character, and the alteration of wave-length is inferred from the change in the frequency of the beats; while mine are eminently *objective*, and are directly intelligible from the visible mechanical actions produced by the forks.

It may be asked, why did I not mention Mr. König's beautiful experiments as a proper preface to my own? Before publishing my results, I examined into the literature of the subject as far as the journals and transactions of societies allowed, and I found nothing that interfered with my claim to the use of the forks, as well as the above application of the principle of the communication of vibrations, and the exhibition of the same to a large audience by means of the lantern. It was only after my communication to the Paris Academy had been published, that my friend Professor Rood, of Columbia College, showed me in König's catalogue the account of his experi-

ments, as above quoted. Had I sooner met with them I would have prefaced my paper with a minute account of his work. As it is, I do all I now can, and here publicly render to M. König the *amende honorable.*

Let us now proceed to examine another paragraph of Dr. Radau's paper, after having perused the account of my experiments from No. 2 to No. 9 inclusive, M. Radau says, "If the forks are mounted on resonators, the change of pitch can also be observed by imparted vibrations. One fork is left upon a table; the other, tuned *unisono*, is strongly vibrated and approached to or moved from the other. If the second fork is in contact with the resonator *only during this motion*, the *first* is *not* put into vibration because the exciting sound is put out of tune by the motion. The imparted vibrations can, however, be obtained by first putting the exciting fork out of concord, by proper means (for instance with wax)."

I have carefully examined into the history of this subject, and have read all the articles referred to by M. Radau in his paper, including his own "*l'Acoustique*," and I feel justified in saying, that surely I could not have desired a clearer or more concise description of the real essential principle of my communication to the Paris Academy of Sciences than is contained in the above quoted paragraph; and after having M. Radau to tell us in his opening paragraph that I have done nothing new, it is in truth very cool in him thus, in a subsequent paragraph, so complacently to appropriate my work.

Thus one M. Radau, a Frenchman, treats the "one Mr. A. M. Mayer, an American."

July 5th, 1872.

Art. XXVIII.—*Preliminary Description of New Tertiary Mammals;* by O. C. Marsh. Part II.

The present communication is a continuation of the article in the preceding number of the Journal (p. 122), in which were described some of the new mammalian remains discovered by the Yale College expeditions to the Rocky Mountain region. Among the animals briefly described in the present paper are several which appear to be Marsupials, the first fossil species of the group detected in this country, and hence of much interest.

Limnofelis ferox, gen. et sp. nov.

A gigantic carnivore, nearly as large as a lion, is represented in our collections by portions of a skull, a fragment of a lower jaw containing the sectorial molar, and by some vertebræ and

other less important parts of the skeleton of the same individual. The remains show that the animal was a typical carnivore, one of the largest and most powerful yet discovered. The tooth preserved resembles the corresponding one of the lion in its general shape, but is proportionally broader anteriorly, the base of the crown being subtrilateral in outline, with the inner side the longest. This tooth was in close contact with the one in front. The zygomatic process of the squamosal is proportionally more massive than in the lion, although similar in form.

Measurements.

Antero-posterior diameter of lower sectorial molar,	24·5 mm.
Greatest transverse diameter,	11·75
Height of tooth above jaw,	14·
Greatest vertical diameter of zygomatic process of squamosal,	32·

This interesting specimen was found, in September last, by Mr. J. F. Page, of the Yale party, near Henry's Fork, Wyoming. The geological horizon was Eocene, or Lower Miocene.

Limnofelis latidens, sp. nov.

A second very large carnivore, but inferior to the preceding in size, is indicated by a last upper premolar, and probably by some other fragmentary remains. This premolar is unusually broad, and is remarkable for its large posterior tubercle, which is two-thirds the size of the main cusp. The anterior tubercle is very small. On the outer face there is a well-marked basal ridge. The crown is 16·5^{mm} in longitudinal diameter, 11·^{mm} in transverse diameter, and 15·^{mm} in height. Another specimen, apparently of this species, is the left lower jaw of a young individual. It contains the canine, and three molars, the last of which is still nearly enclosed in the jaw. The space occupied by the three molars is 46^{mm}.

The only known remains of the species were discovered by Mr. G. M. Keasbey and the writer, last autumn, in the Tertiary beds of Grizzly Buttes, near Fort Bridger, Wyoming.

Limnocyon riparius, sp. nov.

A new species of *Limnocyon*, about the size of a fox, is represented by both lower jaws and a single upper molar from the same animal. The lower jaws are long and massive, and throughout the space occupied by the premolars and molars they maintain nearly the same width and depth. The symphysis is elongated, and the rami were but slightly coössified. There were six teeth behind the canine, all close together and each with two fangs. The last two are tubercular. The canine was large, and near the symphysis.

Measurements.

Space occupied by lower premolars and molars, ...47· mm.
Space occupied by last three molars, ...26·
Antero-posterior diameter of penultimate lower molar,..... 9·
Transverse diameter,..... 5·
Depth of jaw below this molar, ...12·5

The specimens on which this description is based were found, in August last, by Mr. O. Harger, at the same locality as the preceding species.

Limnocyon agilis, sp. nov.

A still smaller species, apparently of the same genus, is well represented by the greater portion of a skull with teeth, and the more important parts of the skeleton of the same individual. In the lower jaws, the premolars are separated from each other and from the canine, and the first premolar has but a single fang. The first upper premolar is separated nearly its own longitudinal diameter from the canine. The penultimate upper molar has its elevated pair of cusps more closely united than in the last species. The present animal had a long tail, and claws resembling those of a fox.

Measurements.

Space occupied by three lower premolars, ...27·6 mm.
Depth of jaw below third lower premolar,.....12·
Antero-posterior diameter of penultimate lower molar,.... 7·75
Transverse diameter,..... 3·6
Length of astragalus,.....21·
Transverse diameter of distal end of humerus, ...27·

The above remains were found by the writer, in September last, in the Tertiary shale of Grizzly Buttes, Wyoming.

Thinocyon velox, gen. et sp. nov.

A small carnivore, about as large as a cat, is represented by a nearly perfect lower jaw with several teeth, and perhaps by some less characteristic remains of other individuals. The jaw somewhat resembles in its proportions that of *Lymnocyon*, but it is more elongated, and the symphysis is more nearly horizontal. The angle of the lower jaw is inflected, thus probably indicating the marsupial affinities of the species. The condyle, also, was evidently but little elevated. The number of teeth in each lower jaw was nine, divided as follows: Incisors 2, canine 1, premolars and molars 6. The incisors are small and compressed. The canine is large, and nearly round at the base. The last two molars are tubercular; and the four anterior teeth compressed, and each has two fangs.

Measurements.

Longitudinal extent of lower premolars and molars,	30·5 mm.
Extent of last three teeth,	16·
Depth of jaw below last molar,	7·5
Length of symphysis,	17·
Longitudinal diameter of canine at base,	3·75
Space occupied by two left incisors,	2·

The specimen on which the present description is based was found, in September last, by the writer, during the explorations of the Yale party in Grizzly Buttes, Wyoming.

Viverravus (?) *nitidus*, sp. nov.

A diminutive mammal, about the size of a weasel, is clearly indicated by a perfect penultimate lower molar, which agrees so nearly with the corresponding tooth of *Viverravus gracilis* Marsh, that the species it represents may for the present be referred to that genus. Other remains in our collections probably pertain to the same species. The crown of this molar is composed of a posterior tubercle, which has its summit near the outer side; next a pair of elevated, pointed cusps, of equal size, the exterior being slightly in advance of the other; and in front a small, slightly bifid tubercle.

Measurements.

Antero-posterior diameter of penultimate lower molar,	4· mm.
Transverse diameter in front,	1·5
Transverse diameter behind,	2·
Height above jaw of central tubercles,	3·

The above specimen was discovered last autumn, by G. G. Lobdell, Jr., in the Tertiary shale near Henry's Fork, Wyoming.

Thinolestes anceps, gen. et sp. nov.

The collections made by the Yale party include the remains of a number of small carnivorous mammals, which are apparently very unlike any hitherto known. In dentition, they somewhat resemble several extinct species, supposed to be of suilline affinities, but their carnivorous characters appear unmistakable. All apparently had the angle of the lower jaws inflected, and present other marsupial characters, although in general structure they are very different from any known form of that group. The teeth in the present genus are similar to those of *Limnotherium*, and the two genera are evidently nearly related. In the complete description, the characters and affinities of this peculiar group, which may be called *Limnotheridæ*, will be fully discussed.

The lower jaws in this species are short and stout. The teeth agree in number and general form with those of *Limno-*

therium tyrannus Marsh, and may be divided as follows: Incisors 2–2, canines 1–1, molar series 7–7. There are seven teeth, also, in the upper jaw behind the canine. The first premolar above and below has only a single fang. The upper molars have an external pair of pointed cusps, and on the inner side the first and second true molars have a pair of nearly confluent cones, of which the anterior is much the larger. The last upper molar has but one inner cone. The lower jaws are coössified at the symphysis, but the suture is visible externally. The head of the humerus is much like that of the opossum, and the distal end has a similar supra-condilar foramen. The astragalus resembles that of the raccoon. The animal had a long slender tail, and was nearly as large as an opossum. Its food was probably, in part, insects.

Measurements.

Longitudinal extent of upper molar series,	28· mm.
Extent of three upper true molars,	15·5
Extent of three lower true molars,	18·
Antero-posterior diameter of last lower molar,	6·6
Transverse diameter,	4·
Depth of jaw on posterior face below last lower molar,	10·

This species is represented in the Yale Museum by the more important part of several skeletons, which were found, last autumn, by Mr. J. F. Quigley, Mr. G. G. Lobdell, Jr., and the writer, in the Tertiary deposits of Western Wyoming.

Telmalestes crassus, gen. et sp. nov.

This genus, which closely resembles *Thinolestes* in the dentition of the lower jaws, may be readily distinguished from it by the upper molars, which have the inner pair of cones of the first and second true molars separate, and of nearly equal size. The last upper molar has but one inner cusp. So far as is now known, the dental formulæ of the two genera are the same, and in the proportions of the jaws they are very similar. The present species was about as large as a raccoon, but the lower jaws are much stouter, and are ankylosed at the symphysis.

Measurements.

Longitudinal extent of lower molar series,	37· mm.
Extent of three lower true molars,	23·5
Antero-posterior diameter of last lower molar,	9·5
Transverse diameter,	5·5
Extent of last three upper molars,	18·
Transverse diameter of last upper molar,	7·8

The specimen on which the above description is mainly based was discovered, last September, near Henry's Fork, Wyoming, by Mr. O. Harger, of the Yale party.

Limnotherium affine, sp. nov.

A species of *Limnotherium*, somewhat smaller than *L. tyrannus* Marsh, is well represented in the Yale Museum by portions of a skull with teeth, both lower jaws, and a considerable part of the skeleton of the same animal. The lower jaws are much more slender than in *L. tyrannus*. The lower molars have their crowns more compressed, and the canine is but little larger at the base than the first lower premolar. This and the following premolar have each but one fang. The upper true molars closely resemble those of *Thinolestes anceps*.

Measurements.

	mm.
Longitudinal extent of lower molar series,	32·
Extent of last three lower molars,	17·
Antero-posterior diameter of last lower molar,	7·
Transverse diameter,	4·
Depth of jaw on posterior face below last lower molar,	9·
Antero-posterior diameter of lower canine at base,	2·3

The type specimen of this species was found, last September, at Grizzly Buttes, by Mr. J. F. Quigley, of the Yale party.

Orohippus pumilus, gen. et sp. nov.

The remains on which the following description is principally based consist of two separate series of upper molar teeth, four of each. They indicate a new genus of small solipeds, nearly allied to *Anchitherium*, and which possibly may include the species described by the writer as *A. gracile*. The crowns of the upper true molars are composed of a pair of external cusps similar to those of *Anchitherium*. There are two corresponding inner tubercles, from which ridges extend obliquely to the anterior inner margin of the outer cusps, but the anterior ridge is divided so as to form an intermediate anterior tubercle. All the teeth preserved have a distinct basal ridge. The species was about the size of *Anchitherium gracile*, and appears to have had a long slender tail.

Measurements.

	mm.
Longitudinal extent of four upper posterior molars,	27·
Antero-posterior diameter of last upper molar,	7·
Transverse diameter,	8·
Antero-posterior diameter of penultimate upper molar,	7·5
Transverse diameter,	8·5

The specimens here described were found, in August last, at Grizzly Buttes, Wyoming, by Mr. G. M. Keasbey and the writer.

Helohyus plicodon, gen. et sp. nov.

An interesting genus of small pachyderms, nearly related to *Hyracotherium*, is indicated by an upper molar tooth in perfect

preservation. An isolated third upper premolar, and probably some other fragmentary specimens from the same deposits, may belong to the same species. The molar tooth is apparently the last of the upper series. The crown is composed mainly of four cones of nearly equal size. On the outer side, there is a pair of regularly conical tubercles, quite similar in size and shape. At the inner anterior corner, there is another cone, and behind, and partly inside of this, is the inner posterior cone. Between the anterior pair of cones, there is a smaller tubercle. The crown is surrounded by a strong basal ridge, and the entire surface of the enamel is delicately wrinkled. The species was about the same size as *Hyracotherium leporinum* Owen, from the London Clay.

Measurements.

	mm.
Antero-posterior diameter of last upper molar,	9·
Transverse diameter,	10·2
Distance between summits of external pair of cones,	4·
Distance between summits of anterior pair of cones,	5·3

The known remains of this species were found by Mr. H. D. Ziegler and Mr. G. G. Lobdell, Jr., last summer, at Grizzly Buttes, near Fort Bridger, Wyoming.

Thinotherium validum, gen. et. sp. nov.

A portion of a lower jaw containing the last true molar, and two isolated lower molars, which were found near, and may pertain to the same animal, indicate a new ungulate mammal, about as large as the preceding species. The ultimate molar resembles in its form and structure of crown the corresponding tooth of *Elotherium lentum* Marsh. The four principal tubercles are similar, and have the same relative position, but at the posterior extremity of the crown there is but a single small cusp, and the antero-interior cone was but slightly, if at all, divided. There is a marked lateral construction of the crown between the anterior and central pair of cones, and no basal ridge on the sides.

Measurements.

	mm.
Antero-posterior diameter of last lower molar,	11·
Transverse diameter in front,	7·
Transverse diameter through central pair of cones,	6·
Distance between summits of central cones,	3·1
Antero-posterior diameter of first lower true molar,	8·4

The only known specimens of this species were discovered last autumn, near Henry's Fork, by Mr. G. G. Lobdell, Jr.

Passalacodon litoralis, gen. et sp. nov.

Several small mammals, evidently insectivores, about the size of the European hedge-hog, were among the interesting discov-

eries of the Yale party last year. One of these is at present known by a lower jaw with the last two molars perfect, and by a few other fragmentary remains. The jaw was rather slender and compressed, and much prolonged backward at the angle. The two molars preserved have their crowns composed of an anterior pair of high cusps, and a posterior pair less elevated. At the anterior and posterior margin of each molar, there is a small intermediate tubercle which projects beyond the border, especially in the penultimate molar. The rami were apparently not coössified. The inner incisor is large and near the symphysis.

Measurements.

Antero-posterior diameter of last lower molar,	5· mm.
Transverse diameter,	3·
Antero-posterior diameter of penultimate lower molar,	4·8
Transverse diameter,	3·1
Depth of jaw below first lower premolar,	6·

This unique specimen was found, in September last, near Henry's Fork, by Mr. J. F. Quigley, of the Yale party.

Anisacodon elegans, gen. et sp. nov.

Another genus, nearly allied to the preceding one, may be established on a lower jaw with teeth, which belonged to an animal about the same size as the one last described. In the present specimen, the last lower molar is smaller than the penultimate. In both, the cavities between the cusps are much more deeply excavated than in the same molars of *Passalacodon*, and the small intermedial tubercles are less prominent.

Measurements.

Antero-posterior diameter of last lower molar,	4· mm.
Transverse diameter,	3·9
Antero-posterior diameter of penultimate lower molar,	4·6
Transverse diameter,	3·1
Depth of lower jaw on posterior face below last molar,	6·5

The only known specimen of this species was found, last autumn, by the writer, near Henry's Fork, Wyoming.

Centetodon pulcher, gen. et sp. nov.

A small insectivorous mammal, not larger than a mole, is likewise indicated by part of a lower jaw, with the last true molar well preserved. Several other specimens in our collections probably should be referred to the same species. The lower molar is quite different from that of the recent small insectivores, and resembles somewhat the corresponding tooth in *Centetes*, although probably there is little affinity between the two genera. The posterior part of the crown is formed by a

low tubercle, which is separated by a deep notch from the anterior elevated portion. The latter is composed of three pointed cones, the front one being the highest.

Measurements.

Space occupied by last two lower molars,	3·6	mm.
Antero-posterior diameter of last lower molar,	1·8	
Transverse diameter,	1·1	
Depth of jaw below last lower molar,	3·5	

The specimen here described was found, last September, by the writer, near Henry's Fork, Wyoming.

Part III.

Nearly all the remains briefly described in this section of the present communication belonged to quite small animals, many of them insectivorous, and several evidently marsupials. In the complete description, now in course of preparation, these various species will be fully described, and their more exact affinities determined.

Stenacodon rarus, gen. et sp. nov.

A new genus of very small mammals, apparently related distantly to *Hyopsodus*, may be established on a single last lower molar, in good preservation, which is one of the rarities of our collections. The crown of the tooth is remarkably narrow. It is composed essentially of four main cusps, nearly of the same size, and a larger posterior tubercle. The main cusps are arranged in two transverse pairs, and the posterior pair are the highest. There is no basal ridge. The species was somewhat smaller than *Hyopsodus paulus* Leidy.

Measurements.

Antero-posterior diameter of last lower molar,	6·5	mm.
Transverse diameter through anterior pair of cones,	2·9	
Transverse diameter through posterior tubercle,	2·	
Height of posterior pair of cones above jaw,	2·7	

The above specimen was found by the writer, last autumn, near Henry's Fork.

Antiacodon venustus, gen. et sp. nov.

This species, which is about the same size as *Homacodon vagans*, is at present represented only by part of a lower jaw, with the characteristic lower molar, so often alone preserved. The crown of the present tooth has a similar composition to that of the same molar in *Homacodon*. The four principal cones stand in nearly opposite pairs, but the posterior tubercle is less widely

separated from the central pair of cones, and the inner anterior cusp has its summit distinctly cleft. The crown, also, is proportionally shorter longitudinally. There is a distinct basal ridge on the front and outer sides of the crown.

Measurements.

Antero-posterior diameter of last lower molar,	6·2 mm.
Transverse diameter through anterior pair of cones,	3·6
Transverse diameter through central pair of cones,	3·6
Height of anterior inner cusp above jaw,	3·7

The only known specimen of this species was found, last September, by the writer, near Henry's Fork, Wyoming.

Bathrodon typus, gen. et sp. nov.

In this genus, the first and second lower true molars have crowns with a similar composition to those of *Limnotherium*, but the anterior pair of cusps are more elevated, and the posterior pair are nearly equal in size. The last lower molar is quite different from the corresponding tooth in that genus. It is more like the preceding molar with the addition of a posterior tubercle, which is near the inner margin. The present species is based mainly on a portion of a lower jaw containing the last three molars. They indicate an animal about as large as *Limnotherium elegans* Marsh, and one probably allied to that species.

Measurements.

Longitudinal extent of last three lower molars,	12·5 mm.
Antero-posterior diameter of last lower molar,	5·
Transverse diameter,	3·5
Height of penultimate lower molar above jaw,	2·6

The only known remains of this species were found by Mr. F. Mead, Jr., at Grizzly Buttes, near Fort Bridger, Wyoming, in September last.

Bathrodon annectens, sp. nov.

Another species, about as large as a rabbit, is indicated by a fragment of a lower jaw with the last lower molar perfect. In its composition, and the position of its cusps, this tooth resembles the corresponding molar of *Anisacodon elegans*, but differs from it in having the anterior half of the crown narrower than the posterior portion. The former is elevated, and has its inner cusp the highest. There is no distinct basal ridge.

Measurements.

Antero-posterior diameter of last lower molar,	5·8 mm.
Transverse diameter in front,	3·4
Transverse diameter through posterior half,	3·5
Depth of jaw on posterior face below last lower molar,	10·6

This unique specimen was discovered, in September of last year, near Henry's Fork, by Mr. F. Mead, Jr., of the Yale party.

Mesacodon speciosus, gen. et sp. nov.

This species and genus is based essentially on a nearly perfect lower jaw, with most of the teeth in good preservation. In its general features, the jaw resembles that of *Limnotherium*, and the molars are similar in composition to those of *L. elegans*, although considerably narrower. The teeth form a continuous series. The canine is large and compressed, and almost in contact with the symphysis. There are three premolars, and three true molars. The first premolar had but a single fang. The second is compressed, and the third is very similar to the next true molar. The last lower molar is narrower than the penultimate. The jaw is short, twisted longitudinally, and was not coössified with its fellow. The lower border was produced posteriorly, and the angle inflected. The remains indicate an animal about the size of the preceding species, and probably insectivorous.

Measurements.

Longitudinal extent of six lower molars,	20·2 mm.
Extent of three lower true molars,	12·2
Antero-posterior diameter of last lower molar,	4·3
Transverse diameter,	3·
Depth of jaw on posterior face below last lower molar,	7·

The jaw described above was found by the writer, last September, at Grizzly Buttes, Wyoming.

Hemiacodon gracilis, gen. et sp. nov.

A genus of small mammals, apparently insectivorous, with molar teeth resembling those in *Mesacodon*, is well represented by portions of several lower jaws, and possibly by other characteristic remains. All appear to belong to the same species, which was somewhat smaller than that last described. The lower jaws preserved are rather slender and compressed. The teeth form a continuous series, and the dental formula appears to be as follows: Incisors 2, canine 1, premolars 3, and molars 3. There were evidently two small incisors, and the canine was but little larger. The first premolar has but a single fang. The two following are compressed, subtriangular at the base, and both quite different from the first true molar. There was an external basal ridge on the crowns of the lower molars. The jaws were not coössified at the symphysis. The lower margin was produced posteriorly, and the angle inflected.

Measurements.

Longitudinal extent of nine lower teeth,	20·5 mm.
Extent of premolar and molar series,	17·2
Extent of true molars,	11·

Antero-posterior diameter of last lower molar,..... 4· mm.
Transverse diameter,..... 2·4
Depth of jaw below last lower molar,..... 6·3

The type specimen of this species was discovered, last autumn, near Henry's Fork, Wyoming, by Mr. G. G. Lobdell, Jr. Other specimens were found in the same region by Mr. O. Harger, Mr. J. J. DuBois, and Mr. T. G. Peck, of the Yale party.

Hemiacodon nanus, sp. nov.

A much smaller species, of the same genus apparently, is indicated by a right lower jaw, with the last four molars in perfect preservation. The teeth in this specimen have crowns with the same composition as in the preceding species, and there is the same marked difference between the last premolar and the first true molar. The teeth preserved have a distinct basal ridge. The jaw is less compressed than in the larger species. It indicates an animal about the size of a weasel, whose food was probably insects.

Measurements.

Longitudinal extent of last four lower teeth,.....11· mm.
Extent of three lower molars,..... 9·
Antero-posterior diameter of last lower molar,..... 3.5
Transverse diameter,..... 2·
Depth of jaw below first lower true molar,..... 4·6

The specimen on which the above description is based was discovered by Mr. O. Harger, in September last, near Henry's Fork, Wyoming.

Hemiacodon pucillus, sp. nov.

A still smaller species, not larger than a mole, is indicated by a fragment of a lower jaw containing the penultimate molar in good condition. The jaw was proportionally more compressed than in the specimen last described, but the tooth preserved agrees closely in the composition of its crown with the corresponding molar of that species. On the outer side of the crown, there is a distinct basal ridge.

Measurements.

Antero-posterior diameter of penultimate lower molar, ...2·3 mm.
Transverse diameter,.....2·
Height above jaw of anterior tubercles,.....1·7
Depth of jaw below this molar,.....3·7

This specimen, the only known remains of the species, was found in September, 1870, by Mr. H. B. Sargent, of the Yale party. The locality was at Grizzly Buttes.

Centetodon altidens, sp. nov.

A fragment of a lower jaw in our collections contains a penultimate molar, which agrees so nearly in its main features with the last lower molar of *Centetodon pulcher*, that the species it represents may provisionally be referred to that genus, although the species differ widely in size and other respects. The tooth preserved is remarkable for its great height above the jaw. The notch between the low posterior tubercle and the elevated anterior trifid portion of the crown is not so deep as in the small species, and more like that in the genus *Centetes*. There is a faint basal ridge around the crown, except on the inner side.

Measurements.

	mm.
Longitudinal extent of last two lower molars,	5·5
Antero-posterior diameter of penultimate lower molar,	3·
Transverse diameter,	2·3
Height above jaw,	3·1
Depth of jaw below penultimate molar,	6·

This specimen was found by the writer, last autumn, near Henry's Fork.

Entomodon comptus, gen. et sp. nov.

Another genus of insectivores is represented by several isolated teeth, one of the most characteristic of which is a last lower molar, in excellent preservation. This tooth is very narrow, and its crown is composed of a low posterior tubercle slightly bifid; a pair of elevated central cones, the outer being the highest, and slightly in advance of the other; and a small compressed anterior tubercle. Behind the inner central cone is a deep depression. There is no basal ridge. The tooth indicates an animal about as large as a weasel. It is probable that the small mammal referred provisionally by the writer to the genus *Viverravus*, under the name *V. nitidus*, may belong to the present genus. The species is rather smaller than the one here described.

Measurements.

	mm.
Antero-posterior diameter of last lower molar,	5·3
Transverse diameter through central cones,	2·5
Height of outer central cone above jaw,	4·4
Height of anterior tubercle above jaw,	3·4

The type specimen of this species was found near Henry's Fork, last September, by Mr. G. M. Keasbey.

Entomacodon minutus, gen. et sp. nov.

A small insectivorous mammal, about as large as a mouse, is indicated by a fragment of a lower jaw with the last molar per-

fect, and probably by some other equally characteristic remains. The crown of the lower molar has its main cusps very similar to those of *Entomodon*, but all are pointed. The outer of the three anterior points is the highest, and the posterior cusp is trifid. There is no basal ridge. An upper true molar found near this specimen, and perhaps belonging to the same animal, resembles in the composition of its crown the first upper true molar in the genus *Erinaceus*.

Measurements.

Antero-posterior diameter of last lower molar,	2·2 mm.
Transverse diameter,	1·
Height above jaw,	2·
Depth of jaw below last lower molar,	2·5

The specimens now representing this species were found, last autumn, near Henry's Fork, by Mr. O. Harger.

Centracodon delicatus, gen. et sp. nov.

One of the treasures of our collections is a small, nearly perfect lower jaw, containing seven teeth, most of them in good preservation. The specimen clearly represents an insectivore, about as large as a mole, and apparently a marsupial. The jaw is slender, and its lower border regularly curved longitudinally. There were three true molars with pointed cusps, and four premolars more or less compressed. The first and second premolars are inclined forward, and separated from each other. The last molar has a low, sharp, posterior tubercle, and in front a high pointed external cusp, with two small inner tubercles.

Measurements.

Longitudinal extent of seven posterior lower teeth,	12·8 mm.
Extent of last three molars,	6·
Antero-posterior diameter of last lower molar,	2·
Transverse diameter,	1·2
Depth of jaw below last lower molar,	3·

The above specimen was discovered, in September of last year, near Henry's Fork, by Mr. F. Mead, Jr.

Nyctilestes serotinus, gen. et sp. nov.

An interesting genus of very small bats is indicated by part of a lower jaw with the last three molars perfect. On the outer side, these molars resemble those of *Nyctitherium*, but differ essentially from the same teeth in that genus in having the pair of pointed anterior tubercles of equal height. The jaw is slender, and proportionally less deep than in *Nyctitherium*. The present species was somewhat smaller than *N. velox*.

Measurements.

Longitudinal extent of last three lower molars,	4·2	mm.
Antero-posterior diameter of last lower molar,	1·3	
Transverse diameter,	1·	
Depth of jaw below last lower molar,	2·	

This specimen, the only known remains of the species, was found by the writer, last September, at Grizzly Buttes, Wyoming.

Ziphacodon rugatus, gen. et sp. nov.

A new carnivore, about the size of a civet cat, is represented in our Wyoming collections by the anterior part of a lower jaw, and probably by other less important remains. The premolars in this specimen have their main cusps peculiarly sharp and effective. Their anterior and posterior tubercles, also, are pointed, and placed near the base of the crown. The first premolar is large, and near the canine. The latter was of medium size, and inserted in the jaw more nearly vertically than in most carnivores. The adjoining incisor was large. The premolars have the enamel of the crown coarsely wrinkled.

Measurements.

Longitudinal extent of canine and five next lower teeth,	30·	mm.
Extent of four premolars,	19·2	
Antero-posterior diameter of third premolar,	6·	
Transverse diameter,	3·	
Depth of jaw below fourth premolar,	8·5	

The type specimen of this species was found by Mr. J. J. DuBois. The locality was near Henry's Fork.

Harpalodon sylvestris, gen. et sp. nov.

Another new genus of carnivores, apparently allied to *Viverravus*, is indicated, also, by part of a lower jaw containing the last two premolars, and the following tubercular molar. The former differ from the corresponding teeth in *Viverravus*, in the absence of the upper posterior tubercle on the third lower premolar. On the fourth premolar, this tubercle is rudimentary. The premolars preserved are much compressed, and have the anterior tubercle well developed. The present species was somewhat larger than *V. gracilis* Marsh.

Measurements.

Longitudinal extent of last two premolars and first true lower molar,	16·2	mm.
Antero-posterior diameter of first true molar,	5·3	
Antero-posterior diameter of last premolar,	5·8	
Transverse diameter,	2·7	
Height above jaw,	4·6	

The above specimen was found by Mr. O. Harger, near Henry's Fork.

Harpalodon vulpinus, sp. nov.

A larger species, apparently of the same genus as the preceding, may be based on part of a lower jaw containing the last premolar. Some other isolated specimens probably belong to the same species. The premolar has the posterior tubercle proportionally more developed than in *H. sylvestris*, and is consequently broader at this part of the crown. The main cusp is less elevated.

Measurements.

Space occupied by four lower premolars,	22· mm.
Antero-posterior diameter of last premolar,	7·
Transverse diameter,	2·3
Height above jaw,	4·3
Depth of jaw below last premolar,	8·

The known remains of this species were found by Mr. T. G. Peck, in September last, near Henry's Fork, Wyoming.

Orotherium Uintanum, gen. et sp. nov.

This genus is nearly allied, apparently, to *Lophiotherium*, but differs from the known remains of that genus in having, on the second lower premolar, a prominent posterior tubercle. In the true lower molars, also, the anterior inner cone is slightly bifid, a character not indicated in the figures given of the corresponding teeth of *Lophiotherium*. The present species is based on a nearly entire lower jaw, with the last six teeth in perfect preservation. The first true lower molar is very similar to the fourth premolar, but is rather broader anteriorly. The second premolar is narrow, with the anterior cusp compressed and separated from the posterior tubercle by a wide notch. The lower teeth resemble those of *Lophiotherium sylvaticum* Leidy, as well as those of the smaller species, *L. Ballardi* Marsh, and both these species should doubtless be placed in the genus *Orotherium*. The relations of this genus to *Orohippus* cannot at present be fully determined.

Measurements.

Longitudinal extent of last six lower teeth,	47· mm.
Extent of last three lower molars,	26·5
Antero-posterior diameter of last lower molar,	11·5
Transverse diameter,	5·
Antero-posterior diameter of fourth lower premolar,	7·
Transverse diameter,	5·

This specimen was found near Henry's Fork, Wyoming, by the writer, in September last.

Helaletes boops, gen. et sp. nov.

Among the Tapiroid mammals in the Green River Tertiary deposits, there are two distinct genera which have been referred to *Lophiodon*. Dr. Leidy has given the name *Hyrachyus* to one of these, which embraces the larger species, and the other may be called *Helaletes*. In this genus the last lower molar has a third, posterior lobe. The upper molars resemble those of *Lophiodon* The astragalus differs widely from the Tapiroid type, and in its narrow oblique condyles is very similar to that of the Equidæ. Other characters of the genus will be given in the full description.

The present species is based upon the greater portion of a skull with teeth, and the more important parts of the skeleton of the same individual. The teeth agree in size with those of *Lophiodon nanus* Marsh, but the last upper molar has a small tubercle on the outer margin between the cusps, which appears to be wanting in the type specimen of the latter species. There are also other differences of importance. Both species doubtless belong to the same genus.

Measurements.

Longitudinal extent of last three lower molars,	33· mm.
Antero-posterior diameter of last lower molar,	12·2
Depth of jaw below last lower molar,	21·
Antero-posterior diameter of last upper molar,	11·1
Transverse diameter,	11·5
Length of astragalus,	27·
Width between condylar ridges,	11·5

The type specimen of this species was discovered, last autumn, at Grizzly Buttes, Wyoming, by Mr. G. G. Lobdell, Jr.

Part IV.

Paramys robustus, sp. nov.

A new rodent, with lower molar teeth similar to those of *Paramys*, but a much larger animal than the known species of that genus, is represented by two lower molars, and by other less important remains. An isolated incisor probably belongs to the same species. The lower molars preserved are proportionally broader than those in *Paramys delicatus* Leidy, and the penultimate molar is more constricted medially, the notch on the inner side being nearly as deep as the external depression. The known remains of this species indicate an animal somewhat larger than the common woodchuck (*Arctomys monax* Gm.).

Measurements.

Antero-posterior diameter of last lower molar,	6·5 mm.
Transverse diameter,	5·5

Antero-posterior diameter of penultimate lower molar,....6· mm.
Transverse diameter, ...6·4
Transverse diameter of incisor, ...4·

The specimens above described were found by Mr. G. G. Lobdell, Jr., and Mr. G. M. Keasbey, in the lower Tertiary deposits of Grizzly Buttes and Henry's Fork, Wyoming.

Tillomys senex, gen. et sp. nov.

A small rodent, about the size of a rat, is represented in our Wyoming collections by a fragment of a lower jaw with the second molar in place, and apparently by some other uncharacteristic remains. The crown of this molar is somewhat worn, but was composed essentially of an anterior transverse crest, and a pair of posterior tubercles, the outer and larger one being connected by a small intermediate tubercle with the outer posterior angle of the anterior lobe. The jaw in the present species is slender, and the tubercle at the anterior margin of the masseteric fossa is under the center of the second molar.

Measurements.

Space occupied by four lower molars,.....11· mm.
Antero-posterior diameter of second lower molar,..... 2·
Transverse diameter, ... 1·8
Depth of jaw below second molar,..... 5·

The known remains of this species were found, in September last, by the writer, near Henry's Fork.

Tillomys parvus, sp. nov.

A smaller species, which appears to agree generically with the specimen last described, may be established on a lower jaw, also containing the second molar. In this tooth, the longitudinal connecting ridge, or tubercle, between the anterior and posterior parts of the crown, is more nearly central. The masseteric fossa, moreover, terminates in front just at the anterior margin of the last lower molar. The species was but little larger than a mouse.

Measurements.

Length of lower molar series,.....7·1 mm.
Antero-posterior diameter of second lower molar,.....1·9
Transverse diameter, ...1·5
Space between incisor and first lower molar,.....3·

This specimen was found by Mr. O. Harger, at Grizzly Buttes, Wyoming, in September last.

Taxymys lucaris, gen. et sp. nov.

The existence of another small rodent, evidently belonging to the Sciuridæ, is clearly proved by a fragment of an upper jaw,

with the first two molars in position. A vertebra found with this specimen probably belonged to the same animal, which was rather smaller than the common flying squirrel (*Pteromys volucella* Desm.). The first upper molar is nearly round, and diminutive, as in many of the recent squirrels. The second upper molar has its crown composed of two main transverse ridges, which start from the outer side, and meet in a prominent inner and slightly bifid tubercle. There are two low ridges outside of the main pair, which meet in the same tubercle.

Measurements.

Space occupied by first two upper molars,	2·5 mm.
Antero-posterior diameter of second upper molar,	1·7
Transverse diameter,	2·
Transverse diameter of first upper molar,	1·

The above remains were found, last autumn, by the writer, near Henry's Fork, Wyoming.

Sciuravus parvidens, sp. nov.

A diminutive rodent, with molar teeth resembling those of *Sciuravus*, is evidently represented in our collections by a lower jaw containing the third molar, part of an upper jaw with the penultimate molar, and several isolated teeth. These remains indicate an animal about half the bulk of *Sciuravus undans* Marsh. The lower incisor is more convex in front than in that species. The jaw is short and deep, and the masseteric fossa ends in front under the second molar. The upper penultimate molar has three fangs, and the last one had four.

Measurements.

Space occupied by three posterior lower molars,	5·2 mm.
Antero-posterior diameter of third lower molar,	2·
Transverse diameter,	1·9
Depth of jaw below second lower molar,	5·3
Transverse diameter of lower incisor,	1·2

The remains at present representing this species were found, last autumn, at Henry's Fork and Grizzly Buttes, Wyoming, by Mr. G. M. Keasbey and the writer.

Colonymys celer, gen. et sp. nov.

Another small rodent, about the size of the animal last described, is indicated by several isolated molars, which differ widely from the corresponding teeth in any genus of this group from the Green River Tertiary deposits. A typical upper molar in perfect condition has its crown composed of four principal cusps, regularly arranged in two pairs. The outer pair are entirely separated from each other. The inner pair are very near together, and have their summits turned toward the center

of the tooth. The two anterior cusps are connected by an outward curving basal ridge. A similar ridge passes from the outer posterior cone inward, but does not reach the opposite cusp. This upper molar, which is apparently the penultimate, measures 2·4 mm. in antero-posterior diameter, and 2·1 mm. in transverse diameter. The known remains of the present species were found, last autumn, near Henry's Fork, by Mr. H. D. Ziegler and Mr. A. B. Mason, of the Yale party.

Apatemys bellus, gen. et sp. nov.

A new and peculiar genus of very small mammals may be based on part of a lower jaw, with the penultimate molar in place, and well preserved. Extending through the base of the specimen is a portion of a large rodent-like incisor. The molar is of the insectivore type, and the animal should probably be placed with that group. The crown of this tooth has its posterior half deeply excavated, with the outer rim of the cavity the highest, and rising at the inner posterior angle into a pointed tubercle. The anterior half of the crown consists of a transverse pair of high pointed cusps, opposite each other, and connected together. An elevated basal ridge, rising into a sharp inner cusp, completes the anterior margin. The large incisor is oval in transverse section, and extends under all the molars. The animal was about as large as a mole.

Measurements.

Antero-posterior diameter of penultimate lower molar,	2·3 mm.
Transverse diameter,	2·
Depth of jaw below,	5·6
Transverse diameter of incisor,	1·6

This unique specimen was found, last September, near Henry's Fork, by Mr. G. G. Lobdell, Jr.

Apatemys bellulus, sp. nov.

Another diminutive mammal, apparently of the same genus, but somewhat smaller than the species last described, is well represented by a lower jaw with the last three molars perfect. The penultimate molar agrees in the composition of its crown with that of *A. bellus*. In the last lower molar, the outer border of the posterior cavity forms a slightly curved longitudinal ridge, which terminates in a small tubercle. The molar teeth are narrow, and the jaw compressed. The cavity for the incisor extends below all the lower molars.

Measurements.

Space occupied by last three lower molars,	6· mm.
Antero-posterior diameter of last lower molar,	2·1
Transverse diameter,	1·6
Antero-posterior diameter of penultimate lower molar,	2·
Transverse diameter,	1·7

This interesting fossil was found, last autumn, near Henry's Fork, Wyoming, by Mr. G. M. Keasbey.

Entomacodon angustidens, sp. nov.

A very small insectivore, which appears to belong to the genus *Entomacodon*, left its remains in the Green River Tertiary deposits, and our collections contain a left lower jaw, with the last premolar and the two following molars in good preservation. The molars agree essentially in the composition of their crowns with those of *E. minutus*, but the three anterior cusps are nearer together, and the one in front is nearly as high as the others. The specimen indicates, also, a smaller animal than the type of that species. The jaw is much compressed, and the teeth are very narrow. The last premolar resembles the adjoining molar, but has the anterior cusp rudimentary.

Measurements.

	mm.
Space occupied by last four lower teeth,	5·5
Antero-posterior diameter of last lower premolar,	1·6
Antero-posterior diameter of penultimate lower molar,	1·7
Transverse diameter,	1·
Depth of jaw below last lower molar,	2·5

This specimen was found by Mr. J. J. DuBois, at Grizzly Buttes, Wyoming, in September of last year.

Triacodon grandis, sp. nov.

The genus *Triacodon* was established, by the writer, on a single lower premolar, which differed widely from any corresponding tooth then known. The species thus represented was called *T. fallax*, and its possible marsupial affinities were suggested.* The researches of the Yale party during the past year, in the same region where the original specimen was found, have added something to the knowledge of this peculiar mammal, but much still remains to be ascertained. A portion of a skeleton was found at Grizzly Buttes by the writer, and fortunately the peculiar premolar was in the jaw, although the other teeth were too imperfect for study. The jaws were stout, but not deep, and the lower border was convex longitudinally. There was a prominent canine, and the last lower molar was tubercular. The skull had a distinct sagittal crest. The humerus was slender, and curved as in the otter. The animal was probably a carnivorous marsupial.

A second and much larger species of the genus is represented by the corresponding right lower premolar, in excellent preservation. It agrees closely in its main features with the type specimen of *T. fallax*, but has a distinct antero-external basal

* This Journal, vol. ii, p. 123, August, 1871.

ridge. It indicates, moreover, an animal several times the bulk of that species. Probably other remains of both species were found by our party, but have not been recognized as pertaining to this genus.

Measurements.

Antero-posterior diameter of last lower premolar,	5· mm.
Transverse diameter,	5·8
Height of anterior cusp above jaw,	5·2
Height of exterior cusp above jaw,	8·

This rare specimen was found, by Mr. O. Harger, in the shale near Henry's Fork. The geological horizon was essentially the same as at Grizzly Buttes.

Triacodon nanus, sp. nov.

A much smaller species, apparently not more than one-half the bulk of *T. fallax*, is indicated, likewise, by the peculiar last lower premolar. This tooth, like that in the other species, has two fangs. There is a faint basal ridge, and the three pointed cusps, that give the crown its character, are more nearly of equal size than in either of the larger species.

Measurements.

Antero-posterior diameter of last lower premolar,	3· mm.
Transverse diameter,	3·
Height of anterior cusp above jaw,	2·5
Height of exterior cusp above jaw,	4·

This specimen, the only remains of the species at present known, was discovered at Grizzly Buttes, in September last, by Mr. G. G. Lobdell, Jr.

Euryacodon lepidus, gen. et sp. nov.

A small mammal, doubtless an insectivore, is represented by a fragment of an upper jaw containing the last two molars in perfect condition. Our collections contain other characteristic fossils which appear to be specifically identical with this specimen. The teeth preserved agree nearly in the composition of their crowns with the molars described by Dr. Leidy under the name, *Palæacodon verus*, but each has its inner margin produced into a small tubercle. In the penultimate upper molar, this tubercle is especially prominent. The outer margin, also, of these molars has but a single faint indentation between the external cusps. Both teeth are surrounded by a distinct basal ridge. The specimens preserved indicate an animal about as large as a weasel.

Measurements.

Space occupied by last two upper molars,	4·3 mm.
Antero-posterior diameter of penultimate upper molar,	2·4
Transverse diameter,	3·8
Transverse diameter of last upper molar,	3·2

The type specimen of this species was found, last autumn, at Grizzly Buttes, by the writer, and other remains were discovered, at the same locality, by Mr. O. Harger.

Palæacodon vagus, sp. nov.

Another small insectivore, about the same size as the preceding species, is clearly indicated by part of an upper jaw, with the last three molars perfect. In this specimen, the last two upper teeth are broader transversely than in *Euryacodon lepidus*, and both lack the inner tubercle. The outer margin of the crown and the basal ridge are very similar in the corresponding teeth of the two specimens. The first upper true molar has externally a deeper notch between the outer cusps, and at each external angle the basal ridge rises into a small tubercle. It is possible that the small tooth mentioned by Dr. Leidy, in his description of *Palæacodon verus*, may prove to belong to the present species. In that case his specific name may be retained for the animal represented by the larger tooth, which mainly is described, and the smaller species may bear the name here given.

Measurements.

Space occupied by last three upper molars,	7· mm.
Antero-posterior diameter of penultimate upper molar,	2·7
Transverse diameter,	4·
Antero-posterior diameter of last upper molar,	2·1
Transverse diameter,	3·6

The only known remains of this species were found at Grizzly Buttes, Wyoming, by Mr. F. Mead, Jr.

Yale College, New Haven, August 15th, 1872.

Postscript.

The original specimens of the fossil mammals described by the writer in this and preceding articles are carefully preserved in the Museum of Yale College. The dates of publication of the principal papers are as follows: The two articles in Volume II. of this Journal (pages 35–44, and 120–127, July and August, 1871) were published together, in pamphlet form, and widely distributed, June 21st, 1871. The species there described, therefore, bear that date. The various parts of the present communication were issued separately as follows:—Part I, July 22d, 1872; Part II, August 7th, 1872; Part III, August 13th, 1872; and Part IV, August 17th, 1872,—the date of publication being printed on each pamphlet.

The brief descriptions here given are merely preliminary to a full description, with illustrations, now in preparation.

Yale College, August 19th, 1872.

ART. XXIX.—*On certain Relations between the mean motions of the Perihelia of Jupiter, Saturn, Uranus and Neptune;* by Professor DANIEL KIRKWOOD.

IN Mr. Stockwell's able memoir* on the secular variations of the planary orbits, it is shown that the mean motions of the perihelia of Saturn, Uranus and Neptune are as follows:

Saturn, ...22″.4608479
Uranus,† 3.7166075
Neptune, ... 0.6166849

Denoting these values by N^{vi}, N^{vii}, and N^{viii}, respectively, we have,

$$N^{vi} - 7N^{vii} + 6N^{viii} = 0''.1447048, \quad . \quad . \quad . \quad (1)$$

As these quantities depend upon the masses of the planets, some of which are not very accurately known, it seems probable that the second member of (1), if precisely determined, would be 0. The influence of the small planets, Mercury, Venus, the Earth and Mars, is, in this case, quite inconsiderable; no probable change in the received masses of Uranus and Neptune would reduce the second member of (1) to 0; and, finally, the mass of Jupiter is more accurately determined than that of any other planet. There remains, then, the large planet Saturn, the received value of whose mass is derived from Bessel's measurements of the elongation of the sixth satellite. The value of this element, according to the Königsberg astronomer, is 176″.55. Now, it will be found that a value of 177″.17 (which exceeds Bessel's by 0″.62), corresponds to a mass, $\frac{1}{3\,4\,0\,4\,0}$, which substituted in Stockwell's formulas renders the equation

$$N^{vi} - 7N^{vii} + 6N^{viii} = 0, \quad . \quad . \quad . \quad (2)$$

accurately true. The difference, 0″.62, is less than that between the determinations of the equatorial diameter of Saturn by the best observers.

If equation (2) be exact, the corresponding relation between the mean longitudes of the perihelia will be obvious, and it must follow that *the perihelia of no three of the four outer planets can simultaneously have the same mean longitude.* In short, if L^{v}, L^{vi}, L^{vii} and L^{viii}, represent the mean longitudes of the perihelia of Jupiter, Saturn, Uranus and Neptune, respectively,

* Smithsonian Contributions, Washington, 1872.

† The mean motion of Jupiter's perihelion is precisely the same.

their mutual relations will probably be expressed by the following equations:

$$L^{vi} - 7L^{vii} + 6L^{viii} = 180°, \quad . \quad . \quad . \quad (3)$$
$$L^{v} - L^{vi} + 6(L^{vii} - L^{viii}) = 0, \quad . \quad . \quad . \quad (4)^*$$

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the ammoniacal platinum bases.*—Cleve has continued his elaborate investigation of the ammoniacal compounds of platinum, and has described a number of new compounds containing aniline and ethylamin. By heating chloride of plato-semi-diamine in a sealed tube, with weak alcohol and an excess of aniline, a white crystalline powder is obtained, which has the formula,

$$Pt\left\{\begin{matrix} 2NH_3 \\ 2(NH_7C_6) \end{matrix}\right\} Cl_2.$$

This salt gives with chlorplatinite of potassium a voluminous rose-colored precipitate corresponding to the green salt of Magnus, and having the formula,

$$Pt\left\{\begin{matrix} 2NH_3 \,.\, Cl \,.\, Cl \\ 2(NH_7C_6)Cl \,.\, Cl \end{matrix}\right\} Pt.$$

The nitrate and oxalate of this base have respectively the formulas,

$$Pt\left\{\begin{matrix} 2NH_3 \\ 2(NH_7C_6) \end{matrix}\right\} 2N\Theta_3, \text{ and } Pt\left\{\begin{matrix} 2NH_3 \\ 2(NH_7C_6) \end{matrix}\right\} C_2O_4 + \Theta H^2.$$

By evaporating the chloride of this base with aniline, water, and a little alcohol, a new chloride is obtained containing one atom less of aniline, and having the formula,

$$Pt\left\{\begin{matrix} 2NH_3 \\ NH_7Cl_6 \end{matrix}\right\} Cl_2.$$

By the action of iodine upon the first chloride ammonia is disengaged, and a yellow powder having the formula,

$$Pt\left\{\begin{matrix} NH_3 \\ NH_7C_6 \end{matrix}\right\} I_2,$$

is precipitated. We may consider this iodide as derived from the chloride,

$$Pt\left\{\begin{matrix} NH_3 \,.\, NH_3 \\ NH_7C_6 \,.\, NH_7C_6 \end{matrix}\right\} Cl_2,$$

by the loss of the two external molecules, NH_3 and NH_7C_6. Under the same circumstances the isomeric chloride,

* In the memoir already referred to, Mr. Stockwell has shown that while "the mean angular distance between the perihelia of Jupiter and Uranus is exactly 180°," the longitude of each may differ from its mean place to a considerable extent. In fact, the present angular distance is but 157°.

$$Pt\left\{\begin{matrix}NH_3 \cdot NH_7C_6\\NH_3 \cdot NH_7C_6\end{matrix}\right\}Cl_2,$$

disengages the two external molecules of aniline, and we have iodide of platosamin,

$$Pt\left\{\begin{matrix}NH_3 \cdot I\\NH_3 \cdot I\end{matrix}\right.$$

The second chloride above mentioned unites also with platinous chloride to form a part which crystallizes in very brilliant, thin, micaceous scales.

When aniline is dissolved in a concentrated boiling solution of sulphate of plato-semi-diamine, colorless prismatic crystals are obtained having the formula,

$$Pt\left\{\begin{matrix}2NH_3\\3NH_7C_6\end{matrix}\right\}SO_4.$$

When chloride of platosamine, $Pt(NH_3 \cdot Cl)_2$, is heated with aniline, water, and a little alcohol, thin nacreous scales are obtained, which have the formula,

$$Pt\left\{\begin{matrix}NH_3 \cdot NH_7C_6\\NH_3 \cdot NH_7C_6\end{matrix}\right\}Cl_2,$$

and are isomeric with the salt first described. The chlorplatinite of this compound is a slightly soluble, crystalline, buff-colored powder. The author describes also the normal sulphate and nitrate.

By boiling the chloride of plato-semi-diamine with ethylamine, Clève obtained a chloride having the formula,

$$Pt\left\{\begin{matrix}2NH_3\\2NH_7C_2\end{matrix}\right\}Cl_2,$$

which gives a beautiful green chlorplatinite. The solution of the chloride gives with potassic iodide a precipitate having the formula,

$$Pt\left\{\begin{matrix}NH_3\\NH_7C_2\end{matrix}\right\}I_2.$$

The isomeric chloride,

$$Pt\left\{\begin{matrix}NH_3 \cdot NH_7C_2\\NH_3 \cdot NH_7C_2\end{matrix}\right\}Cl_2,$$

is easily obtained by the action of ethylamine upon chloride of platosamine. It is much less soluble than the compound first named. It yields a slightly soluble, green chlorplatinite, and a normal sulphate with 6 atoms of water of crystallization.—*Bull. de la Société Chimique*, 1872, p. 294. W. G.

2. *On compounds containing phosphorus and platinum.*—Schützenberger has continued his investigations of the very remarkable compounds of platinous chloride, and has arrived at interesting results. When the compound, $P(C_2H_5O)_3PtCl_2$, is treated with ammonia, it becomes fluid and gradually dissolves. The solution gives on evaporation the chlorhydrate of a new base,

$$PN(C_2H_5O)_3H_3Pt \cdot N_2H_4 \cdot 2HCl.$$

The compound, $P_2(C_2H_5O)_6PtCl_2$, also dissolves in ammonia, and yields the chlorhydrate,

$$P_2(C_2H_5O)_6Pt \cdot N_2H_4 \cdot 2HCl.$$

The methyl compounds, $P(CH_3O)_3PtCl_2$ and $Pt_2(CH_3O)_6PtCl_2$, yield similar compounds. It appears probable that the radical $P(C_2H_5O)_3Pt$ may be isolated by the action of zinc on the chloride. All of these compounds are derived from the bodies, PCl_3PtCl_2 and $(PCl_3)_2PtCl_2$, which are formed by the action of phosphoric chloride, PCl_5, upon spongy platinum. By the action of these substances upon alcohol the compounds, $P(C_2H_5O)_3PtCl_2$ and $P_2(C_2H_5O)_6PtCl_2$, are formed.—*Berichte der Deutschen Chem. Ges., Jahrgang* v, p. 390. W. G.

3. *On the specific heat of carbon.*—H. F. Weber has re-determined the specific heat of carbon in the form of diamond and of graphite. The author employed the ice calorimeter of Bunsen, and arrived at the remarkable result that the specific heat of carbon increases with the temperature more rapidly than that of any other known substance. In the case of diamond it is trebled for an increase of temperature from 0° to 200° C. The author's experiments were made with two diamonds weighing respectively 447 and 634 milligrammes. Preliminary trials showed that these had the same specific heats within the limits of the necessary errors of experiment. For twelve different temperatures almost uniformly distributed in the interval from 0° to 200° thirty-three observations were made. These gave for the mean specific heat the parabolic formula:

$$Co - t = 0{\cdot}0947 + 0{\cdot}000497t - 0{\cdot}00000012t^2.$$

By means of this formula the true specific heat, or the quantity of heat necessary to raise the temperature of the unit of weight one degree at t°, may be determined, since we have:

$$t \cdot Co - t = \int_0^t \gamma t \cdot dt$$

and $$\lambda t = 0{\cdot}0947 + 0{\cdot}000994t - 0{\cdot}00000036t^2.$$

This gives the following values for diamond:

0°	$\gamma = 0{\cdot}0947$
50°	$\gamma = 0{\cdot}1435$
100°	$\gamma = 0{\cdot}1905$
150°	$\gamma = 0{\cdot}2357$
200°	$\gamma = 0{\cdot}2791$

In the case of graphite the author, from want of snow, made only two determinations. These gave the equations:

$$\left.\begin{aligned} Co - t &= 0{\cdot}1167 + 0{\cdot}0008t \\ \lambda t &= 0{\cdot}1167 + 0{\cdot}0016t \end{aligned}\right\}$$

These results explain the discrepancies in the determinations of the specific heats of carbon by other physicists. They show that diamond at about 525° C. would have a specific heat of 0·52 or $\frac{6{\cdot}3}{12}$, as the law of Dulong and Petit requires. Weber considers

his result as furnishing a strong argument against the law in question, as in his opinion the law loses all chemical and physical value as soon as it is shown to depend essentially upon the temperature. The author promises a further investigation of this subject, which is of great importance for the relation between true specific heat and internal work.—*Berichte der Deutschen Chem. Ges., Jahrgang* v, p. 303. W. G.

4. *What determines Molecular Motion?—The Fundamental Problem of Nature;* by Mr. JAMES CROLL.—Mr. Croll closes an article of 25 pages in the July number of the Philosophical Magazine with the following remarks:

"Molecular physics has made great advance of late years; but it has not made much advance in that particular direction which can be of service in explaining how molecular motion in organic nature is determined. It is thought, however, by the advocates of the physical school that although at present we are unable to explain how organic nature can be built up by the play of the ordinary chemical and physical forces, yet at some future day, when we shall have come to know far more of molecular physics than we do at present, then we may be able to explain the mystery. This is the cherished hope of modern evolutionists, and of the advocates of the physical theory of life. But it is a mental delusion, a dream which will never be realized. A little consideration might satisfy any one that chemistry and physics will never explain the mystery of nature.

The terms light, heat, electricity, magnetism, &c., are different names which we apply to different modes of molecular motion; and it is true that at present little is known regarding the nature of these modes of motion; but notwithstanding this we have reason to conclude that, although we knew all that absolutely can be known regarding them, yet it *would not afford us any explanation* of the cause of the determination of molecular motion in organic nature.

The character of a cause may often to some extent be judged indirectly from the nature of the effects produced. It is from the effects produced that we know, for example, that that mode of molecular motion called heat differs from that mode called electricity. The effects do not as yet enable us to determine wherein this difference consists; but it enables us to conclude with certainty that there is a difference. Effects which are electrical we refer to that unknown mode of motion called electricity. We do not refer them to that mode called heat, because the effects are different from those which we ascribe to heat. Each mode of motion, each energy, is distinguished by the effects which it produces. Determination of the molecules of matter according to the objective idea of a plant or an animal, is an effect which is constantly taking place in organic nature. To attribute this effect to electricity, for example, would be far more absurd than to attribute electrical effects to gravitation or to heat; for the difference between this effect and any electrical effect is immeasurably

greater than between electrical effect and any effects produced by heat, or by gravitation, or by any other of the forces of inorganic nature. It would be far more rational to attribute all the phenomena of the inorganic world, say, to heat, than to attribute the determination of molecular motion in the organic world to chemical and physical energies.

It must now be obvious that nothing which can be determined by the comparative anatomist, no biological researches, no microscopic investigations, no considerations regarding natural selection or the survival of the fittest, can solve the great problem of nature; for it lies in the background of all such investigations. The problem is molecular. From the hugest plant and animal on the globe down to the smallest organic speck visible under the microscope, all have been built up molecule by molecule; and the problem is, to explain this molecular process. If one plant or animal differs from another, or the parent from the child, it is because in the building-up process the determinations of molecular motion were different in the two cases; and the true and fundamental ground of the difference must be sought for in the cause of the determination of molecular motion. Here in this region the doctrine of natural selection and the struggle for existence can afford no more light on the matter than the fortuitous concourse of atoms and the atomical philosophy of the ancients. This, I trust, will be rendered still more evident when we come to examine in detail the arguments advanced by modern evolutionists in support of thier fundamental hypothesis, 'that the whole world, living and not living, is the result of the mutual interaction, according to definite laws, of the forces possessed by the molecules of which the primitive nebulosity of the universe was composed.'"—*Phil. Mag.*, xliv, 24.

5. *On the Separation of Yttria and Ceria from Zirconia and Iron;* by J. W. Taylor, F.G.S. (From a letter to one of the Editors.)—The solution in HCl is precipitated by ammonia, and boiled for a few minutes. An excess of oxalic acid is then added and the whole boiled for half an hour; the zirconia and iron will be dissolved and the yttria and ceria remain as a white precipitate, which, washed, dried and ignited, is redissolved in HCl, again precipitated, and the moist precipitate, dissolved in as little acid as possible, dropped into a strong solution of carbonate of ammonia —which will dissolve the yttria precipitate. A slight trace of ceria will also be dissolved? which may be eliminated by repeating the process.

II. Geology and Natural History.

1. *On Quebec and Carboniferous Rocks in the Teton Range;* by Prof. F. H. Bradley, of the Hayden Exploring Expedition, from a letter to J. D. Dana, dated Teton Cañon, Idaho, July 26th, 1872.—I have to report the discovery of a few small trilobites, unmistakably of Quebec Group age, in the base of the mass of limestones which overlie the central granites of this Teton range.

The limestones are continuous up to the typical Carboniferous, full of *Productus*, *Zaphrentis*, etc. That which I can consider as plainly Quebec Group is about 400 feet thick; partly argillaceous, blue and mostly pebbly; then follows about 600 feet of a drab to pale buff, somewhat vesicular, magnesian limestone, entirely without fossils, which I am obliged to consider, from both character and position, as representing the "cliff" limestone of the Mississippi valley; and this, I believe, is immediately overlaid by true Carboniferous, though the direct connection was covered where I made the section. From the character of the section here, and its similarity to that seen in Malade valley, I am led to expect similar results there when I work out its details, and that this same Quebec Group age must finally be made to include the basal portion of the so-called Carboniferous limestone, through a large portion of this region. The fossils are so few and fragmentary, at least in most places, that it is not surprising that they have been overlooked heretofore. But for having suspected the age from the character of the rock, I should probably have given up the search long before finding the fossils.

We start to-morrow for the ascent of the Grand Teton, and are sanguine of success, although the profile of the easiest slope shows in *one* part a rise of 63°, and *most* of the peak reaches 48°.

Dr. Hayden is said to have left Bozeman on the 17th inst. We hope to meet him in the Firehole Basin about August 20th.

2. *On Changes of Climate during the Glacial epoch;* by James Geikie, F.R.S.E. (Geol. Mag., vols. viii, ix.) Professor Geikie discusses in this memoir of 70 pages the Scottish glacial deposits and their relation to those in England and Ireland, the valley grounds and cave deposits of England, the later glacial deposits of Switzerland and Italy, and adopts Mr. Croll's theory of the physical cause of changes of climate, that referring it to the eccentricity of the earth's orbit.

The following are the conclusions, which the author considers as established.

(1.) That at some distant period (according to Mr. Croll's calculations, upward of 200,000 years ago), owing to the eccentricity of the earth's orbit being at a high value, and the winter of our hemisphere happening to fall in aphelion, a climate of intense severity covered Scotland, Ireland, and the major portion of England with a massive sheet of snow and ice. At the same time similar conditions characterized the mountainous and northern regions of Europe and America.

(2.) That the greater contours of the land were assumed at a much earlier date than the advent of the Glacial epoch, and therefore guided the flow of the ice from the high grounds to the sea.

(3.) That, while the ice moved along the line of the principal valleys, it yet disregarded minor undulations of the ground, and overflowed considerable hills.

(4.) That the till, "grundmoränen," and "moraines profondes" are the materials which gathered underneath the ice,—the general

prevalence of smoothed and striated stones showing that the deposits referred to cannot have been derived from rocks above the level of the *mer de glace.*

(5.) That one result of glacial action was the erosion of rock-basins.

(6.) That intense glacial conditions were interrupted by intervening periods characterized by mild and even genial climates,—the changes of climate being indirectly due to the precession of the equinoxes, which, during a period of extreme eccentricity, would gradually cause the ice-cap to shift from one pole to the other.

(7.) That these interglacial climates are represented in Scotland by stratified deposits intercalated with the till, and containing in places mammalian and vegetable remains; in England by beds in the boulder-clay, and by some portions of the valley-gravels and cave-deposits, with paleolithic implements and bones of the extinct mammalia; on the continent by similar deposits; in America by layers of peat, with buried trees and extinct mammalia.

(8.) That the intermingling of northern and southern forms in the caves and river-gravels points rather to former oscillations of climate than to periods of strongly-contrasted summers and winters,—the arctic mammalia indicating both the gradual approach and the disappearance of glacial conditions; the southern forms being memorials of genial climatal conditions by which the cold or glacial periods were interrupted.

(9.) That the earlier stage of the Glacial epoch embraced several cold and warm periods; but how many the mutilated nature of the records does not at present enable us to say.

(10.) That the climate of the earlier cold periods was more severe than it became in subsequent glacial periods of the same great cycle.

(11.) That similarly the warmth of the interglacial periods was probably greater in the earlier than in the later stages.

(12.) That the disappearance of the last ice-sheet or confluent glaciers in Britain was followed by a period when it is probable that our islands were joined to the continent.

(13.) That this continental condition of Britain may have supervened at a time when the climate was cold and ungenial, and the arctic mammalia may then have revisited our land.

(14.) That the upheaval of land in the north of Europe, which joined Britain to the continent, was accompanied by a corresponding depression in the south.

(15.) That during this movement a large part of Italy was submerged, and deposits of sand filled up the rock-basins, which in all probability had been scooped out in former ice-ages at the mouths of certain Alpine valleys that open upon the plains of Piedmont.

(16.) That the fossils of these sands indicate a temperature for the Mediterranean similar to what obtains at present.

(17.) That during this depression in the south of Europe continental Britain attained to the enjoyment of a mild climate.

(18.) That paleolithic man, and species of mammalia characteristic of the temperate and warm-temperate zone, may have abounded in our country at this time, and left their relics in caves and river-beds.

(19.) That while the mild period continued, subsidence ensued in northern Europe, by which means Britain, from the north of Scotland down to the valley of Thames, was submerged,—the submergence reaching to a depth in Wales and Scotland of about 2000 feet below the present sea-level; and that Scandinavia, Denmark, Holland, northern Germany, northern Russia, and the northern regions of North America, were also carried below the level of the waves. (Formation of the kames, eskers, åsar, etc.)

(20.) That this depression in northern Europe was accompanied by a movement of elevation in the south, as indicated by the old alluvium, with remains of extinct mammalia overlying the marine sands of the plains of Piedmont.

(21.) That if the upheaval in the south at all equalled the degree of subsidence in the north, there must have been land-communication between Europe and Africa,—the soundings between Sicily and Cape Bon indicating the existence of a submarine platform at a less depth than 100 fathoms.

(22.) That the Dürnten lignite beds accumulated while this mild period continued in Italy and the north of Europe.

(23.) That when the submergence was approaching its limits in the northern latitudes of Europe, a change of climate gradually supervened, and icebergs and ice-rafts set sail from the frozen islets that represented Scandinavia and Great Britain and Ireland. (Erratics.)

(24.) That consequently such a change of climate could not have been due to geographical causes.

(25.) That during the submergence in northern Europe, the glaciers of Switzerland advanced and covered up with "newer moraines" some portion of those deposits which had gathered during the preceding mild period.

(26.) That similarly in Italy the Alpine glaciers stole out from their deep valleys, and, entering upon the plains of Piedmont, partially eroded the accumulations which had formed in their absence, but were unable to clear out the buried rock-basins which are inferred to occur at Ivrea and Rivoli (any partial erosion caused by this new advance of the glaciers may since have been obliterated by the deposition of "Alpine diluvium," which must have accumulated after the glaciers retired, just as it did before they advanced).

(27.) That if any deposits indicative of a cold sea were at this time formed in the Mediterranean, they must be still under water,—the land in the south of Europe being at that period most probably of greater extent than it is now.

(28.) That the cold of this period did not approach in severity that of the earlier stages of the Glacial epoch.

(29.) That the movement of depression in the north of Europe

was reversed and converted into one of elevation. (Raised beaches; arctic shell clays.)

(30.) That this upheaval again joined Britain to the continent.

(31.) That glaciers during this stage continued to fill the mountain-valleys of Great Britain and Ireland. (Moraines.)

(32.) That in those turbaries and deposits, which can be clearly shown to be of more recent date than this last extension of the glaciers in Britain and the continent, the human relics obtained belong either to the Neolithic period or to still more recent times, and that these relics are never accompanied by the remains of hippopotamus, rhinoceros, or any of the southern forms of mammalia.

(33.) That the climate of Britain during the period of local glaciers was suited to the wants of arctic mammalia, and perhaps the mammoth and Siberian rhinoceros may have survived to this time.

(34.) That as the cold decreased, Britain became densely wooded,—the climate then resembling probably that of Canada before her forests were thinned. (*Megaceros; Bos primigenius; B. longifrons*, etc.)

(35.) That ere long Britain became insulated, and the sea reached to a greater height than its present level.

(36.) That finally the sea retired, and the present order of things obtained.

3. *On the Geology of the Northeastern West India Islands;* by P. T. Cleve. 48 pp. 4to, with 2 plates. (From the Kongl. Svenska Vet. Ak. Handlingar, ix, No. 12. Read Nov., 1870.)—Mr. Cleve, the author of this memoir, made his observations in the West Indies during the winter of 1868–9. He gives much new information with regard to the geology and mineralogy of the northeastern islands, and closes with the following summary of the facts:

From the account given above it is seen that the oldest rocks of the West Indies do not contain fossils, and are, on that account, of an unknown geological age. They occur in Trinidad, and are called the Caribbean series. They extend farther to the west in the northern part of South America. It seems very uncertain whether this series occurs in the other West India islands.

The oldest fossiliferous rocks of the West Indian archipelago belong to the Cretaceous formation.

The Cretaceous formation is observed in Trinidad, Jamaica and in the Virgin Islands, and it is not improbable that the conglomerates, and the metamorphic and igneous rocks of the large islands of Puerto Rico, San Domingo and Cuba may also be found to belong partly to that formation.

In Trinidad the Cretaceous formation seems to be of an older date than the same formation in Jamaica and the Virgin Islands. One Trigonia resembling *T. Boussingaultii* is found in the "older Parian," and this circumstance seems to indicate that the time for the deposit of those beds is about the Neocomian period.

The Cretaceous beds of Jamaica may be classed as a West Indian equivalent to the European Hippurite lime or to the "Turonien" and Gosau deposit.

The fact of the rocks in the West Indian Cretaceous formation being mostly igneous or igneo-sedimentary, evidently proves them to have been heaped up in a time of powerful volcanic activity, and, as the Miocene formation in several places covers the highly disturbed and metamorphosed Cretaceous rocks, in almost horizontal and undisturbed beds, we may conclude that, before the Miocene time, the Cretaceous rocks were raised to a mountain-chain, having a common direction from east to west, and running parallel with the northern coastline of South America.

Fossiliferous beds belonging to the Eocene formation are found in Jamaica, in Trinidad (the San Fernando beds), as also in St. Bartholomew. It may be regarded, too, as very probable that the same formation occurs in St. Martin, Antigua, Guadeloupe (the "pierre à ravets"), Barbados (Scotland), and possibly also in Cuba, San Domingo and Puerto Rico. The Eocene rocks of the West Indies may be classed as equivalents to the lower or middle Eocene formation of Europe (the lower "calcaire grossier" of Paris and "Bracklesham beds" in England.

The Eocene formation contains to a great extent igneous or metamorphic rocks, which fact indicates the activity of the volcanic power also during the Eocene time.

The Miocene formation consists mostly of limestones or marls, and is enormously developed in the West Indies. Limestone strata belonging to the Miocene formation cover large spaces in Cuba, San Domingo, Jamaica, and Puerto Rico. They are also found in Anguilla, Antigua, Barbados and Trinidad. In St. Croix the white marl also seems to belong to the Miocene time. The Miocene formation is continued in the northern part of South America and in Panama.* From the laborious paleontological researches made by Messrs. Moore, Duncan, Sowerby and Guppy, before quoted in several places, it appears that the fossil fauna has a great resemblance to the Miocene fauna of Europe (as in Malta and at Bordeaux, etc.), and also that it shows a close affinity with the still living fauna of the Pacific Ocean and the East Indies. Among the fossil species of the Miocene beds of the West Indies, some are still living in the Caribbean sea.

These facts have led to the supposition that in the Miocene time an open channel existed over Panama to the Pacific Ocean, and also that a connection with Europe existed in form of an archipelago extending from Europe across the ocean to the West Indies. This theory, indicated and developed by Messrs. Duncan, Sowerby, Guppy and Moore, seems very plausible, and it coincides with the hypothesis which Oswald Heer proposed to explain the close affinities between the European Miocene and the still existing subtropical North American flora.

The Miocena fauna of the West Indies does not, however, offer any close affinities with the Miocene fauna of North America.

* Quart. Journ. Geol. Soc., vol. ix, 1853, p. 132.

The thickness of the Miocene strata of the West Indies, as well as their generally undisturbed position and the absence of volanic rocks, indicates that the Miocene time was, in the West Indies, a long period of calm, undisturbed by volanic phenomena.

A further exploration of the Miocene rocks in the West Indies may make it necessary to divide this formation into several subdivisions.

The Pliocene beds of the West Indies occur in Trinidad (the Matura beds) and in Barbados. To the newest Pliocene or Post-pliocene formation, the lime deposits of Brimstone Hill in St. Kitts, and of Basse-Terre (Guadeloupe) ought, most probably, to be referred. As these deposits occur among rocks ejected from still active volcanos, it may be concluded that the latter take their origin from the Pliocene or the Post-pliocene time. The Bahama Islands, the island of Anegada, and a part of Barbuda belong to a very recent time.

From the facts exposed above it may consequently be inferred, that of the two prevailing lines of elevation in the West Indies the one running from west to east originated before the Miocene time, and that the other from N. W. to S. E., commencing with the Bahamas and continuing in the same direction down to Trinidad, was formed after the Miocene time.

In the mineralogical section of the memoir, the following are described as new minerals:

Resanite.—A hydrous silicate of copper and iron, of an olive-green color, uncrystalline and G = 2·06. The analysis afforded

Si 35·08, Cu 23·18, Fe 9·91, H (vol. at 100° C.) 23·15, H (ign.) 8·53=99·85.

It gives the formula, if the iron is protoxide, $\dot{R}^2\,\dot{S}i^3$. It is easily decomposed by hydrochloric acid. Named after Pedro Resano.

Bartholomite.—In yellow nodules, composed of small needles. The analysis gave

S 44·75, Fe 22·71. Mg 0·63, Na 17·08, H 8·08, Na Cl 2·88, insol. 3·56=99·69.

Separating the common salt, the magnesia as sulphate and the impurities, it gives the formula

$$2\dot{N}a\,\ddot{S} + \dot{F}e\,\ddot{S}^2 + 2\dot{H} = \ddot{S}\ 50{\cdot}00,\ \dot{F}e\ 25{\cdot}00,\ \dot{N}a\ 19{\cdot}38,\ \dot{H}\ 5{\cdot}62 = 100.$$

It is related to botryogen.

4. *Devonian and Lower Carboniferous Plants.*—In the Proceedings of the Geological Society of London, published May, 1872, is an interesting paper, by Prof. Heer, on the Fossil Plants of Bear Island, Spitzbergen. As catalogued by him, the flora of this place, which occurs in shales associated with coal, and below the Lower Carboniferous limestone, includes a remarkable mixture of the plants of the Lower Carboniferous or Subcarboniferous of Europe and America, with ferns characteristic of the Upper Devonian. Unless there has been a mixture of plants from two distinct horizons on the part of the collectors, there must thus have been in this high northern latitude a transition from the Devonian flora to that of the Carboniferous. In North America such a transition occurs in Ohio, but in other localities these floras are somewhat

distinct; and in the east the two series containing them are unconformable. Prof. Heer, however, somewhat impairs the value of his paper by maintaining that all his plants are truly Carboniferous, and belong to what he names the "Ursa stage" at the base of that formation. He even goes so far as to hold that the plants of the American Chemung and Hamilton groups must be Carboniferous also. This, however, proceeds from want of acquaintance on his part with the rich Middle Devonian flora of Eastern America, the resemblance of which to that of the Coal-measures, in general facies, and especially in its richness in ferns, has misled other European paleobotanists accustomed to regard the Middle Devonian as comparatively barren in plants, whereas in fact it contains a flora comparable in richness with that of the Coal-formation, though distinct as to species.

Mr. Daintree has recently read before the same society a paper on the Geology of Queensland, Australia, in which he refers to a Devonian flora existing there; and Mr. Carruthers, who has examined his specimens, identifies some of them with species found in the Devonian of North America. We have thus the wonderful fact of the extension of a Lower Carboniferous and Devonian flora accompanied with the characteristic marine organisms of these periods, from 76° north latitude to 20° to 30° south—an indication of remarkable uniformity of climate, and perhaps also of the hardy and world-embracing constitution of the members of these old floras. J. W. D.

5. *Proceedings of the Lyceum of Natural History.*—Vol. i of the Proceedings, containing records commencing with April 4, 1870, has been published as far as page 236, under date of May 8, 1871.—We take from these Proceedings the following:

Prof. Henry Wurtz, in an article (p. 103) on the rock of the Palisades (New Jersey), gives the following analysis of a specimen, having G=2·94, from Prof. Cook (Geol. of New Jersey, p. 215).—

$$\dot{S}i\ 53{\cdot}9,\ \dot{A}l\ 17{\cdot}5,\ \dot{F}e\ 8{\cdot}0,\ \dot{M}g\ 10{\cdot}3,\ \dot{C}a\ 8{\cdot}0,\ \dot{K},\ \dot{N}a\ 2{\cdot}3=100;$$

and, supposing it to consist of labradorite 60 p. c., and hypersthene 40, he gives for the calculated result—

$$\dot{S}i\ 53{\cdot}5,\ \dot{A}l\ 18{\cdot}2,\ \dot{F}e\ 8{\cdot}7,\ \dot{M}g\ 8{\cdot}7,\ \dot{C}a\ 7{\cdot}4,\ \dot{K},\ \dot{N}a\ 2{\cdot}7=99{\cdot}2.$$

[We strongly suspect from the resemblance of the rock to that of the Connecticut trap, and an examination of a specimen of the Palisade rock, that part of the iron was in the state of magnetic iron. The magnetic iron in this rock near New Haven, Ct., is often in octahedral crystals, as may be sometimes seen on weathered surfaces; and the same is true of the Palisade trap examined. The rock appears to be true *dolerite*, the counterpart among eruptive rocks of hyperite among metamorphic rocks. The other constituents are essentially the same that have been obtained in analyses of the New Haven rock.—J. D. D.]

A mica schist filled with minute crystals of kyanite covers large areas, according to Professor D. S. Martin, on New York island on East 42d street, near the Union Depot, and also between 45th and 46th streets, west of Madison avenue; and he remarks that the rock is probably continuous from one point to the other.

Prof. Martin also states (p. 222) that *granular limestone* has been found in the gneiss in East 124th street, which is probably a prolongation of the ridge at Mott Haven and elsewhere in Westchester county.

Dr. J. L. Newberry states, on page 224, that the *iron ore* on the Clingwater, in Wyoming, discovered by Dr. Hayden, contains *23½ p. c. of titanic acid.*

6. *U. S. Geological Survey of the Territories;* F. V. HAYDEN, U. S. *Geologist in charge. Profiles, Sections and other Illustrations designed to accompany the final report of the Chief Geologist of the Survey, and sketched under his directions;* by HENRY W. ELLIOTT. Under authority of the Secretary of the Interior, 1872. —This volume of illustrations contains sixty-five plates and over three hundred engravings, all reproductions of the excellent drawings of Mr. Elliott. Although mostly sketchy outlines, with but few touches, they bring out like portraitures the landscape scenery of the regions, showing even the geological features of the surface and stratification of the rocks. Moreover the kinds of rocks in the different parts of each scene have been mentioned by Dr. Hayden in the explanations of the plates. The views have therefore a high scientific interest, both geological and geographical.

7. *Damouritic garnetiferous schist of Salm-Château.*—Messrs. L. D. DE KONINCK and P. DAVREUX have analyzed a schist looking as if steatitic, and have found it to consist of a hydrous mica affording "perfectly" the compositions of damourite, "K, 3Āl, 6Si, 2Ĥ." Some transparent and slightly elastic mica-like plates in the rock have the same constitution as the rock itself. The garnets are manganesian, or of the variety spessartite.—*Proc. Acad. Roy. Belg.*, April 6, *L'Institut*, July 17.

8. *Bathmodon radians of Cope.*—Prof. COPE stated that the largest mammal of the Eocene formation adjoining those of Wyoming, i. e., of the Wahsatch group of Hayden, was the *Bathmodon radians* Cope, of about the size of the rhinoceros. It was an odd-toed ungulate, with peculiar dental characters. The incisors were well developed above and below as in the tapir, but the dental series was little interrupted. The crowns of the upper molars were all wider than long, and presented mixed characters. On the outer margin one only of the two usual crescents of ruminants was present, but a tubercle represented the anterior one. The one which was present was directed very obliquely inward. Inner crescents were represented by two angles, the posterior forming the inner angular margin of a flat table, the anterior a mere cingulum at its anterior base. The arrangement of these parts was stated to be of interest in connection with the relationships between the types of hoofed animals. The single outer crescent was a ruminant indication, while the inner table resembled the interior part of the crown of *Titanotherium.* It differed, however, in its early union with the outer margin, its edge being thus possibly homologous with the posterior transverse crest in

Rhinoceros. The premolars had two or three lobes with crescentic section arranged transversely. He regarded the genus as allied to *Chalicotherium.*

He stated that the mammalian fauna of Wyoming and Utah more nearly resembled that of the Paris Basin than any yet discovered in our country, and that it had been discovered to contain a still greater number of generalized mammalian forms. One of the most marked of these was the genus Hipposyus, described by Dr. Leidy.

9. *On some New Species of Fossil Mammalia from Wyoming;* by Dr. Jos. Leidy. (From a letter to Mr. Tryon, dated Fort Bridger, July 24th, printed in advance of the Proceedings of the Academy of Natural Sciences of Philadelphia, and issued Aug. 1, 1872.)—The region of Fort Bridger is an immense basin, the bed of an ancient lake, bounded on the south by the Uinta mountains, and extending far north to the Wind River mountains. The deposits of the lake of the Tertiary period are estimated to be about 8,000 feet in thickness. They present the appearance of a succession of terraces or table-lands extending southerly from Green river to the base of the Uintas. The country for the most part is treeless, and, except along the water-courses, nearly a desert. The Tertiary deposits consist of strata so little inclined that they appear to be horizontal to the eye. The strata are composed mainly of clays, soft and crumbling or more or less indurated, often mixed with sand. Friable sandstones and indurated marls, often with abundance of fresh-water shells, also frequently occur. There are often isolated lands surrounded by broad plains or narrower valleys. These isolated lands are named buttes, and resemble great earthworks or huge railway embankments. Frequently their eroded sides gives them the appearance of a vast assemblage of Egyptian pyramids flanking the plains above. Such assemblages of earthworks, pyramids, mounds, piles of truncated cones, &c., rising from a plain, constitute what are named, in various parts of our great West, "bad lands," or "mauvaises terres."

As the buttes crumble away under the effect of the weather, the fossils of their strata become exposed to view.

On the 17th, in company with Dr. J. Van A. Carter and Dr. Joseph K. Corson, U.S.A., I made a trip to the valley of Dry Creek, forty miles from Fort Bridger. Here we encamped, and spent three days in exploring the neighboring buttes for fossils. The most abundant vertebrate remains are those of turtles, the shells of which are frequently met with in little heaps of fragments into which they have been reduced after exposure from the wearing of the buttes. Of mammalian remains the most abundant are those of the tapir-like animal which I have named *Palæosyops paludosus.* We also found a number of more characteristic specimens than I had before seen of the larger species of *Palæosyops major.* Dr. Corson further discovered the remains of a small species which may be named Palæosyops humilis. An upper

molar tooth of this animal measures three-fourths of an inch in diameter. We have likewise found some additional remains of *Hyrachyus agrarius*, and better specimens than I before had of the larger *Hyrachyus eximius*. A well-preserved last lower molar of this species measures an inch fore and aft.

We were fortunate in obtaining the remains of two of the largest and most extraordinary mammals yet discovered in the Bridger Tertiary deposits. One of these was a tapiroid animal exceeding in bulk of body and limb the living rhinoceroses, though the head appears to have been proportionally small. Dr. Carter discovered many fragments of a skeleton of the animal, including a whole humerus, portions of jaws, and a much crushed and distorted cranium. The upper molar teeth have the crown composed of a pair of transverse lobes, with sloping sides and acute summits, separated externally and united internally in a V-like manner. A thick basal ridge bounds the crown in front and behind. A last upper molar measures an inch and a half in the median line fore and aft. The molars in advance are smaller. The lower molars have a trilobed crown. The anterior lobe, larger than the others, extends across the crown and rises in a prominent peak internally. The acute summit is worn away posteriorly. The middle lobe extends about two-thirds across the crown from the other side, and is less prominent than the others. The back lobe, second in size, is thickest internally. The fore and aft diameter of the last lower molar is equal to the corresponding upper tooth. The depth of the lower jaw at the last molar is three and a quarter inches. The humerus is nearly a foot and three-fourths in length and seven and a half inches in breadth at the condyles. I propose to name the great pachyderm of the Uinta country, the UINTATHERIUM ROBUSTUM.

If not the most interesting, the most exciting incident of our exploration of Dry Creek buttes was Dr. Corson's discovery of the upper canine teeth, apparently of the most formidable of carnivores, the enemy of the *Uintatherium*, *Palæosyops*, and other peaceful pachyderms. The teeth resemble in form those of the sabre-toothed tiger. The more perfect specimen consists of nearly nine inches of the enameled crown. In its perfect condition the tooth measured upward of a foot in length, so that it exceeded the canines of the great Brazilian *Machairodus*. The tooth is sabre-like, curved, and compressed conical. Its most remarkable character consists in the lance-head-like form of the terminal three inches. It is thickened at the axis, and impressed and expanded toward the edges, so as to be actually broader in one portion than immediately above. The antero-posterior diameter of the crown near its base is two inches; the thickness over an inch. These canine teeth, terminating in lance-like points, must have proved most terrific instruments of slaughter. Their possessor was no doubt the scourge of Uinta, and may therefore be appropriately named UINTAMASTIX ATROX.

10. *Descriptions of new species of Fossils from the Devonian rocks of Iowa, with a preliminary note on the Formations;* by JAMES HALL and R. P. WHITFIELD.—Published July, 1872, in advance of the Report on the State Cabinet. 22 pp. 8vo, with 4 plates.—Contains descriptions of species of Corals, Brachiopods and Gasteropods. The figures are excellent.

11. *On the Fossil Man of the cavern of Broussé-roussé, in Italy, called the cave of Mentone;* by E. RIVIERE.—This skeleton is very nearly complete, it wanting only some bones of the feet, and also the lower extremity of the left tibia, and the posterior extremity of the calcaneum of the same side, broken by the stroke of the pick-axe which brought the skeleton to light.

The measurements show that the skeleton is one of large size. The skull was very dolicocephalous, and its facial angle good, approaching 85°. It closely resembles the man of Cro-Magnon found in 1868.

The different species of animals occurring in the immediate vicinity of the skeleton are *Felis spelæa*, *Ursus spelæus*, *Ursus arctos*, *Canis lupus*, *Erinaceus*, *Rhinoceros*, *Equus* (a molar), *Sus scrofa* (several teeth), *Bos primigenius*, *Cervus alces*, *Cervus elaphus*, *Cervus Canadensis*, a *Cervus* which may be the stag of Corsica, *Cervus capreolus*, *Capra primigenia*(?), *Antilope rupicapra* (or chamois), and a species of *Lepus*. Among these animals, three especially, the cave Felis and Ursus, and the Rhinoceros, indicate by their presence around the skeleton and at levels above it, the epoch to which the fossil man belonged.

Among the other objects present there are two flint knives, a bone pin cut from the radius of a stag, and 22 canines of the stag perforated.

The bones were all in place, the attitude being that of a man who had died in his sleep just where he was found, that is, on a bed made of ashes, charcoal and burnt stones, and amid the refuse of his daily life.—*Les Mondes*, July 11.

12. *Sharks' teeth of the Crag, supposed to have been bored by man.*—The Geological Magazine for June contains an article by T. McK. HUGHES, on the bored sharks' teeth found in the Crag (Pliocene), in which the author offers "reasons for believing that there is not the slightest evidence for attributing the phenomena in question to the agency of man." The article is illustrated by figures of the bored teeth, natural size.

13. *The Geology and Physics of the Post-glacial period, as shown in the deposits and organic remains in Lancashire and Cheshire;* by T. MELLARD READE, C.E., F.G.S. (Proc. Liverpool Geol. Soc., Nov., 1871).—The author, after giving detailed descriptions of the region and its Post-glacial formations, presents the following conclusions: That after the laying down of the boulder-clay, the land was elevated above its present level, and again depressed below it, the valleys of the present Lancashire and Cheshire rivers having been mainly excavated during this period and a subsequent re-emergence, and stratified drift deposits made

out of the boulder drift; that a re-emergence took place, and a pause, when the *inferior peat and forest beds* were formed; that a second subsidence took place, denuding these peat beds, and making the Formby and Leasowe marine beds; that an upward movement succeeded, and then grew the forest trees, remains of which are seen at the base of the *superior* peat bed; that the last movement of the land, a downward movement, now took place, and, as a consequence, tidal silt was spread over the superior peat bed, and intercalated in the growing peat, the river bed at Crossens was tilted up, and other changes, both formative and denuding, went forward.

14. *The Birds of North America;* by Prof. S. F. Baird, of the Smithsonian Institution.—The publication of a work on the birds of North America, by Prof. Baird, with the coöperation of Dr. T. M. Brewer, of Boston, and Mr. R. Ridgeway, of Illinois, is promised by December 1st, by Messrs. Little, Brown & Co.; and, with such authors, and Dr. Baird at the head, the work will assuredly be one of high merit, and just what is needed. The illustrations will include a drawing of one species of each genus, and also outline figures of the wing, tail, bill and feet; and besides these, one or more figures of the head of each species of North American birds, in most cases of life size. The publishers state that two editions will be issued, one with colored, the other with uncolored, illustrations.

15. *Fossil Cephalopods of the Museum of Comparative Zoology: Embryology;* by Alpheus Hyatt. Bulletin of the Museum, vol. ii, No. 5.—This memoir contains the results of a careful investigation with respect to the embryology and structure of ammonites and related cephalopods, by a study of the shell in its different stages of development, and also by a comparison of its characters with those of the living nautilus.

16. *Boston Society of Natural History.*—Number 3 of part i. of vol. iii, of the Memoirs of this Society, recently issued, contains an elaborate memoir by Elliott Coues, M.D., on the Osteology and Myology of Didelphys Virginiana, with an appendix on its brain, by Jeffries Wyman.

17. *Efflorescent Salt obtained twelve miles from Denver, Colorado,* contains, according to P. Frazer, Jr., sulphate of soda, 63·87 per cent., sulphate of lime 9·70, water 21·88, chloride of sodium, sulphate of magnesia, &c., 4·55.—*Hayden's Report on Wyoming,* 1871, p. 187.

III. Astronomy.

1. *Annals of the Observatory of Harvard College,* vol. vi, 1859–60; vol. vii, *Observations of Solar Spots,* 1847–49; by Wm. Cranch Bond, Cambridge, 1871.—The sixth volume of the Annals of the Harvard Observatory contains a *third* series of zone observations made under the direction of Professors W. C. Bond and G. P. Bond. The first series was published in vol. i, part ii, and included the places of 5500 stars; the second, in vol. ii, part ii,

and included the places of 4484 stars. The tables in vol. vi—the third series—contain the places of 6100 stars between 0° 40′ and 1° 0′ north declination.

Volume vii. comprises brief tables and numerous plates, illustrating the positions and characters of solar spots, from the observations of Prof. Wm. C. Bond during the years 1847–49. The plates number 112. Professor Winlock says, in his preface to the volume, that the drawings, here reproduced, "furnish a more perfect record of the appearance of the sun for a period of upward of two years than any with which I am acquainted, excepting of course the photographic records which have become possible in recent times, but could not be attempted when Prof. Bond made his observations." The plates are engraved with great apparent exactness and beauty.

2. *Astronomical Engravings of Moon-Craters, Sun-Spots, etc.; by the Observatory of Harvard College.*—The Observatory of Harvard College has issued the following circular, dated July 11, 1872, soliciting subscriptions.

"The Director of the Observatory of Harvard College purposes to publish a series of astronomical engravings, which shall represent as nearly as possible the most interesting objects in the heavens as they are seen with the powerful instruments of the Observatory under his charge.

The series will consist of at least thirty pictures, and will embrace the principal planets, moon-craters, sun-spots, solar prominences, nebulas, and spectra of variable stars.

To obtain some assistance toward defraying the expense of printing, as well as to secure for them a more general circulation than can be expected for volumes of Annals of an Observatory, they will be offered to subscribers at the rate of ten dollars for the set. The pictures will be delivered from time to time as they are completed, and they will be followed by some pages of notes and explanations."

The few specimen plates sent us are excellent, and of great interest, those of some sun protuberances being remarkably fine.

3. *Aurora Australis in March.*—Faint streamers of the Aurora Australis were seen for a short time on the evening of March 2d, shortly after 9 P. M. On the same day considerable magnetic disturbances took place, which began at 1 P. M., affecting the declination to the greatest extent. At 1.30 P. M. the maximum east declination occurred; it then gradually diminished, increasing and decreasing alternately until, shortly after 6 P. M., a steady decrease took place, the minimum occurring at 6.30 P. M., a decrease of 25 minutes of arc having taken place during the half hour, while the whole range of the disturbance amounted to 38 minutes of arc. The disturbance continued to a smaller extent until, between 2 and 3 A. M. on the 3rd, a small vibratory movement set in, which lasted until 7.30 A. M., after which the needle resumed its normal position. The horizontal force was comparatively little affected, the whole range of the disturbance amounting only to 0·0268 of

the absolute unit, while the vertical force showed very little change. —*Monthly Record of the Melbourne Observatory*, for March, 1872.

4. *The Sun's Light.*—A letter from Signor Tacchini, of Palermo, to M. Faye, states some new facts with regard to the presence of magnesium in the chromosphere. He says that on the 6th of May last he found in the sun some regions of great extent remarkable for the presence of magnesium, stretching over an arch from 12 to 168 degrees; and that on the 18th he presented to the Spectroscopic Society at Palermo a design of the whole border with indications as to the position of the magnesium, and its unaccountable predominance along the western border. He further states that on the 18th of June the magnesium was found to show itself to the spectroscope around the whole border, that is, the whole chromosphere was invested with vapors of this metal. Under this general ebullition, there was naturally an absence of protuberances, while the flames of the chromosphere were very marked and brilliant; and the more brilliant the flames the greater the amount of magnesium indicated.—*L'Institut*, July 10.

5. *The August Meteors* were observed, on the night of 9–10, at Sheffield Hall, by Prof. C. S. Lyman, aided by some young assistants. Previous to 10½ o'clock no regular watch was kept, but 30 or 40 were noticed. After that the numbers were as follows:

From	10½	to	11,	30,	by 6	observers.
"	11	"	11½,	50,	" "	"
"	11½	"	12,	61,	" "	"
"	12	"	12½,	56,	" 5	"
"	12½	"	1,	59,	" "	" (most of the time).
"	1	"	1½,	42,	" 4	"
"	1½	"	2,	32,	" 2	"
"	2	"	2½,	28,	" 1	"
"	2½	"	3½,	some haze; accurate count not kept; but		

the number was at about the same rate. Several were brilliant, leaving colored trains. At about 8 minutes past 12 one exploded with a bright flash in the east. The paths were not mapped of any, but a large proportion were *conformable* to the usual radiant. Not more than ¾ of the sky was observed most of the time. A more thorough scrutiny would doubtless have made the numbers greater. There was much auroral light in the north all night, with occasional streamers about midnight. No cloudiness in the sky until after 3 o'clock.

Professor R. W. McFarland, of Miami University, Oxford, Ohio, states, in a letter dated Oxford, Aug. 12, that he observed on the morning of the 10th from a quarter before 3 to 5 minutes before 4, and counted in that time 62 meteors.

6. *On two new planets;* by Prof. C. H. F. Peters. (From a letter to one of the Editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., August 17.)—I have obtained the following observations on two new planets, which I found on the night of July 31, and which will be the 122d and 123d of the group of asteroids.:

(1.) *Asteroid* (122).

1872.	Ham. Coll. m. t.	App. α.			App. δ.			No. of comp.
	h.	m.	s.	h.	m.	s.	°	′	″	
July 31,	15	9	37	21	48	56·47	−11	41	54·9	11
Aug. 1,	11	32	49	21	48	22·36	−11	45	1·8	12
" 2,	12	42	0	21	47	39·73	−11	48	57·4	12
" 3,	12	1	16	21	46	59·52	−11	52	38·2	10
" 4,	12	1	18	21	46	17·64	−11	56	31·0	10
" 5,	11	57	8	21	45	35·47	−12	0	21·1	10
" 7,	12	7	10	21	44	9·32	−12	8	13·1	8
" 8,	11	9	40	21	43	28·11	−12	12	4·4	10
" 9,	11	28	53	21	42	44·02	−12	16	5·7	10

The magnitude of the planet is between 11th and 12th.

(2.) *Asteroid* (123).

1872.	Ham. Coll. m. t.	App. α.			App. δ.			No. of comp.
	h.	m.	s.	h.	m.	s.	°	′	″	
Aug. 1,	12	8	29	21	57	30·53	−10	4	55·3	12
" 2,	13	22	13	21	56	39·73	−10	6	42·3	8
" 4,	11	31	8	21	55	4·91	−10	10	15·5	5
" 5,	12	53	38	21	54	11·34	−10	12	15·0	6
" 7,	13	8	15	21	52	27·13	−10	16	16·9	10
" 8,	12	2	38	21	51	37·20	−10	18	17·3	10
" 9,	12	29	53	21	50	43·10	−10	20	26·7	6

The magnitude of this planet is estimated about 12th. On July 31 I succeeded only in obtaining a rough estimate of position, the advanced twilight not permitting accurate measurements. There will be no difficulty in finding the planets again after the moonlight, even without ephemerides.

7. *Spectra of star-shine, night-light, the Zodiacal light;* by C. Piazzi-Smyth.—* * * And what sort of spectrum ought such star-shine and night-light to offer to the observer? Not a sharp, aurora-like line at all, but something, according to the manner and locality of its formation, very much like the spectrum of the last twilight of day. In fact, according to numerous observations on the Sicilian night sky, when free from any accusation of aurora, I found such night-shine to yield a short continuous spectrum; and that culminating, not at the aurora line place of W. L. 5579, but near W. L. 5350.

Now this place evidently corresponds within the limits of error of observation to that of the last residual portion of the continous spectrum of stronger daylight or sunshine (with the eclipse corona also, at W. L. 5322), modified slightly by the absorbing and reflecting powers of the atmosphere. No Fraunhofer lines are seen in such star-shine spectrum for these reasons; 1st, the continuous spectrum is too faint to show any black lines upon it clearly; and 2d, the slit used at the time of observation was too broad to have shown Fraunhofer lines even in noonday shine. Indeed, to see the spectrum of general night star-shine, the slit of the spectroscope had to be opened wider still than in the case of the zodiacal light; but gave then a closely similar spectrum; and thence we are led to the conclusion that the spectrum of the zodiacal light is the same in kind as that of either star-shine or faint sunshine. Whence the further deduction is inevitable, that the

older astronomical theory of the zodiacal light being the solar illumination of infinitely small distant particles such as meteors revolving about the sun, whether in orbits of infra or ultra planetary ellipticity, is spectroscopically maintained; while, that such solar zodiacal light has any physical connection with the essentially terrestrial accompaniment of aurora, is just as eminently negatived by the spectroscope: for "no two spectra," as the lady most truly said in the Royal Observatory at Palermo, "can be more essentially different than those of the aurora and the zodiacal light. They are as different from one another as night from day.—*Monthly Notices Astron. Soc., June, p.* 285.

V. Miscellaneous Scientific Intelligence.

1. *List of Elevations and Distances in that portion of the United States west of the Mississippi River;* collated and arranged by Prof. C. Thomas, Assistant U. S. Geological Survey under Dr. F. V. Hayden. 32 pp. 12mo. Washington, 1872.—We cite here Table XI, of elevations in Colorado, from this valuable catalogue of elevations:—

Names of Points.	Altitude above the sea. *Feet.*
Mount Harvard (Whitney),	14,270
Gray's Peak "	14,145
Mount Lincoln "	14,123
Mount Yale "	14,078
Pike's Peak (Parry),	14,216
Long's Peak,	14,056
Barry's Peak,	13,133
Mount Flora,	12,878
Mount Wright (E. Berthoud's Pass),	11,800
Cherry Creek Divide,	7,575
Denver,	5,317
Golden City,	5,882
Mount Vernon,	6,479
Golden Gate,	6,226
Junction N. and S. Clear Creeks,	6,466
Black Hawk,	7,543
Central City,	8,043
Missouri City,	9,073
Head Virginia Cañon,	9,690
Idaho,	7,149
Georgetown,	8,245
Berthoud Pass,	10,896
Boulder Pass,	11,670
Jones's Pass,	12,400
Argentine Pass,	13,100
Georgia Gulch Pass,	11,487
Ute Pass,	11,200
Vasquez Pass (estimated),	11,500
Hot Springs (Idaho City),	7,050
Hot Springs (Middle Park),	7,725
Soda Springs (near Pike's Peak),	6,515
Gold Hill,	8,636
Bergen's Ranch (Jefferson Co.),	7,752
Jefferson, South Park,	9,842
Tarryall,	9,943
Foot Berthoud's Pass,	9,325
Osborn's Lake,	8,821
Velie's Peak,	13,456
Mount Audubon,	13,402
Timber Line (Parry).	
On Pike's Peak,	12,000
On Snowy Range,	11,800
On Mount Audubon,	11,325
On Long's Peak,	10,800
On Wind River Mountains,	10,160
On Gilbert's Peak (Uinta Mountains. Hayden's survey),	11,100

The pamphlet closes with the following "Remarks:"—

"An examination of the foregoing tables, together with those found in the reports of the surveys of Professor F. V. Hayden for 1870 and 1871, reveals some very important facts in regard to the topography of the west; among which we may mention the following as of general interest.

That the Llano Estacado, or "Staked Plains," at their northern extremity, immediately south of the Canadian river, vary in

elevation from 3,200 to 4,000 feet above the sea; while at the southern extremity, where Captain Pope's line crossed them, they reach an elevation of 4,700. At the north end they are somewhat irregular and broken, the highest point being near the west margin; at the south end they are much more regular, the highest point being near the eastern flank. The average elevation of this extensive table land is about 4,000 feet above the sea.

The average ascending grade along Captain Pope's line, from Preston to the margin of the Llano Estacado, is about ten feet to the mile.

The average ascent along Lieutenant Whipple's line, from Fort Smith to White Sandy creek on the margin of the Llano Estacado, is about six feet to the mile. From White Sandy creek to Laguna Blanco, the highest point on this line east of the Rio Grande, the ascent is at the rate of ten feet to the mile.

Along the line of the Kansas Pacific Railroad, from Kansas City to Denver Junction, the ascending grade averages a little over eight feet to the mile. Along the Union Pacific Railroad, from Papillion (a station a short distance west of Omaha) to Cheyenne, the ascent averages just ten feet to the mile; but if we stop at Sidney it is a little less than eight feet; while from Sidney to Cheyenne it is over nineteen feet to the mile.

The land ascent from Fort Union, at the mouth of the Yellowstone, to Fort Benton, is only about two and a half feet per mile; but from there west to the base of the mountain it increases rapidly until it averages about twenty feet to the mile.

These facts show that from the southern boundary of Colorado to the northern boundary of Nebraska the slope of the great plains is tolerably uniform, while north (measuring east and west) it decreases more rapidly.

This is, doubtless, owing to two facts; *first*, the heaviest mountain mass, from which the supply of *débris* comes, lies directly west of the first section; that is, between the southern boundary of Colorado and northern boundary of Nebraska; *second*, the northern line is not measured directly at right angles with the range. The line along the Yellowstone would give the ascent more correctly.

It would be an interesting problem in mathematical geology (if we may use such a term) to ascertain the immense amount of débris covering these vast plains which has been washed down from the mountains, and therefrom to form some estimate of their original height.

The average elevation of the great mountain plateau which lies between the Black Hills and Wahsatch range is about 6,500 feet above the level of the sea, and is about 1,200 feet above the western borders of the plains, and 2,200 feet above the Salt Lake basin.

The average fall of the principal rivers is as follows:

Of the Rio Grande, from Isleta to El Paso, about five feet to the mile; but from Isleta south for some distance it is about six feet.

That of the Pecos is not more than four feet to the mile.

The Canadian, from the mouth of the Pajarito creek for two hundred miles eastward, is nine feet to the mile.

The Arkansas, from the mouth of the Apishpa river to Fort Atkinson, eight or nine feet.

The South Platte, from Denver to its junction with the North Platte, is nine or ten feet to the mile; while that of the North Platte, from Fort Fetterman to the junction, is only seven feet. The Platte below the junction has an average descent of about six feet to the mile.

The fall of the Missouri river, from Fort Benton to the mouth of the Yellowstone, is about two feet to the mile; and from the latter point to its mouth, near St. Louis, it averages a fraction less than one foot.

Snake river, from the mouth of Ross's Fork, north, about six feet to the mile.

These facts in regard to the average descent of these rivers furnish important data for estimating the probability of utilizing the water from these streams in irrigating the bordering plains."

2. *Effect of change of barometric pressure on human beings.*—Mr. Paul Best has shown that in the destruction of life by diminishing the barometric pressure, the direct cause is the deficiency of oxygen, and that an animal that will die with the pressure reduced to 18 cm. (7 inches) will endure a reduction to 6 cm. (2·4 inches) before life is extinct, if oxygen be added. And the converse is also true that the evil of too great pressure comes mainly from the too large amount in that case of oxygen, dilution with nitrogen prolonging life. He remarks that workmen employed at great elevations would accordingly find benefit in an arrangement for supplying more oxygen; and those occupied in diving for pearls, etc., by a contrivance for supplying nitrogen.—*Les Mondes*, July 11.

3. *The Temperature and Rainfall of July*, 1872; by C. KEUTGEN, Jr., Meteorologist to the Board of Health, County of Richmond (Staten Island), N. Y. (Communicated for this Journal.)—The month of July, 1872, exhibited the highest temperature and greatest rainfall ever recorded on this island, for any one month. The temperature mean was 78·1, the maximum 96, and the minimum 64·2 degrees. The total rainfall amounted to 11·34 inches. On July 26th, 4·29 inches of rain descended within 12 hours.

4. *A Manual of Qualitative Analysis;* by ROBERT GALLOWAY, F.C.S., etc., from the fifth rewritten and enlarged London edition, with illustrations. Philadelphia: Henry C. Lea, 1872. 12mo, pp. 402.—Prof. Galloway's books are deservedly in high esteem, and this American reprint of the fifth edition (1869) of his Manual of Qualitative Analysis, will be acceptable to many American students to whom the English imprint is not accessible. The publisher does not say that the present issue has received the revision or approval of the author, and the absence of this information implies a doubt which a word of affirmative statement would remove.